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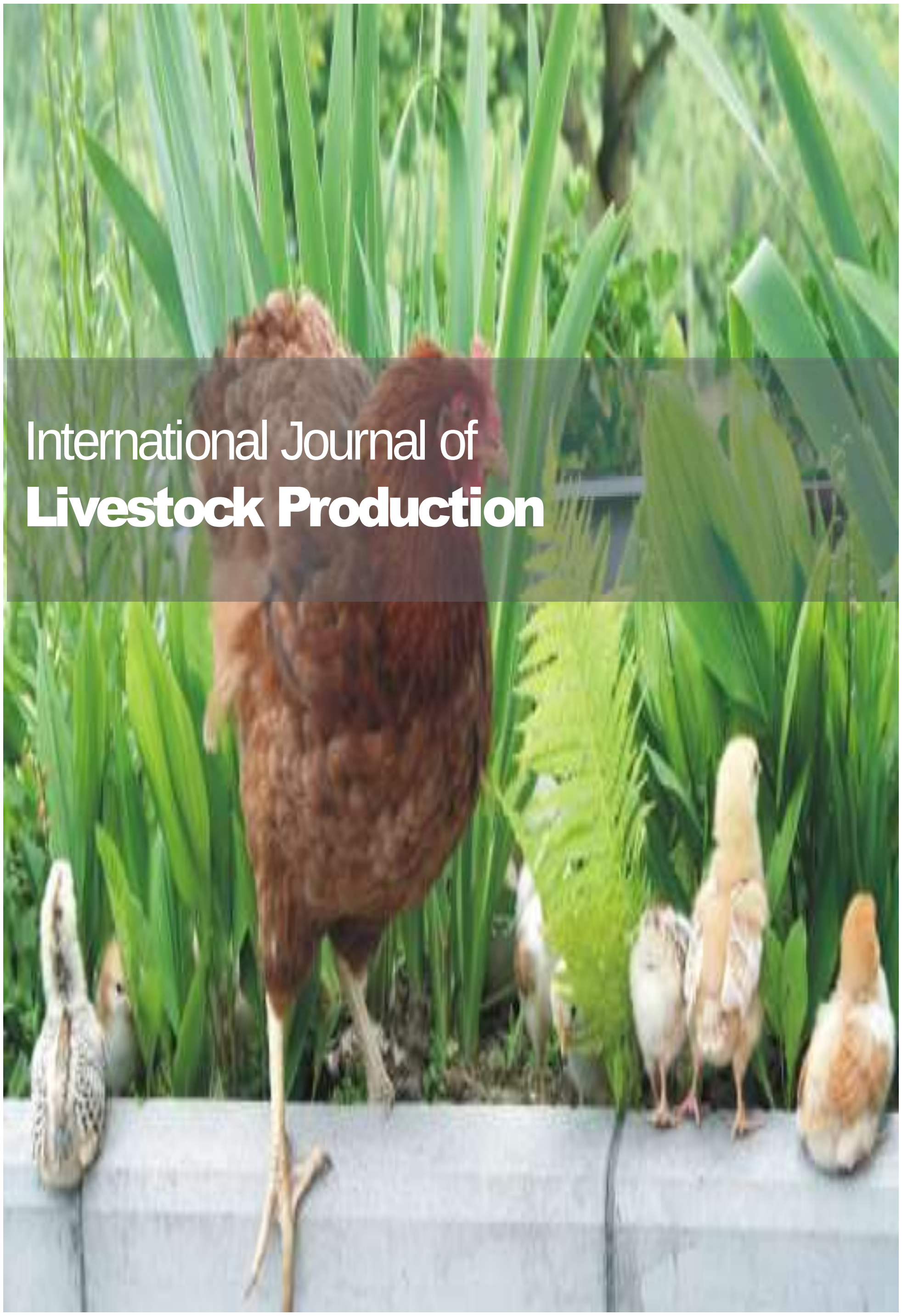

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Table of Content: Volume 9 Number 8 August 2018

ARTICLES

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International Journal of Livestock Production

Full Length Research Paper

Small ruminant production and constraints in Misha Woreda, Hadiya Zone, Southern Ethiopia

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The study was conducted in Misha Woreda, Hadiya Zone, Southern Ethiopia with aim of assessing the production and challenges of small ruminant animals. Data was collected via questionnaire, interview and group discussion. For the study, 4 Kebeles were taken randomly and from each kebele, 20 households were selected purposively based on the experience and involvement of small ruminant production. The result indicated that about 80% of the interviewed respondents were male headed while the remaining 20% were female headed. Among the sample respondents, about 12.5% of the respondents were illiterate and the rest 87.5% were learned at different stages of literacy ranging from elementary to high school grade levels. The prevailing sheep and goat production system common in the study area was mainly extensive (90%) with slight semi-intensive characteristics (10%). The main purposes of rearing sheep and goats in the study area were for home cash income (75%), for security (17.5%) and for slaughter during holidays (7.5%). The results further showed that the main feed source (42.5%) is communal grazing land, 22.5% house leftover and 20% crop residues in the study area. The extensive production system along with feed shortage needs improvement of husbandry practices. Shortage of feed and grazing land and lack of capital are the main problems that hamper the potential of sheep and goat production in the study area. It was concluded that different organizations like government and non-governmental should take these under consideration to improve the production of sheep and goats.

Key words: Production, small ruminant, feed shortage, crop residues.

INTRODUCTION

Livestock is a pillar of the economy in developing countries like Ethiopia. It is one component of agriculture under which the small ruminants are among the major economically important livestock. Thus, they play an important role in the livelihood of resources especially for poor farmers. There are many livestock species in the world. When compared to other countries, Ethiopia has the largest livestock population in Africa that has a considerable contribution to the national economy and the livelihood of the people. According to CSA (2016), Ethiopia has 57.83 million cattle, 28.9 million sheep, and 29.70 million goat population.

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The favourable production environments of Ethiopia have the vast majority of livestock as a base for the rural population's livelihood. However, livestock production and productivity and producers' benefits from livestock production are far below expectations (Solomon et al., 2010). Sheep are among the major economically important livestock as it plays an important role in the livelihood of resource for farmers. Sheep serve as immediate cash need and insurance against crop failure especially where land productivity is low and unreliable due to different factors (Markos, 2006).

Sheep are raised by humans all over the world for a variety of reasons and in many different management systems. Under the extensive systems, sheep have the capacity to express the full range of their natural behaviours, although some aspects of their normal social organization are disrupted. These disruptions include weaning earlier than would occur naturally, segregation of sheep on the basis of age and sex and various husbandry operations, which can cause pain or stress (Kilgour et al., 2008).

Ethiopia is home for a large and diverse livestock resources and favorable production environment (Solomon et al., 2007). Accordingly, Misha Woreda which is found in Hadiya zone, Southern Ethiopia is known to be potential and suitable for livestock productions like sheep. However, the output of the livestock is influenced by different factors. For instance, Belete (2009) indicated that although various research and development activities have been carried out in the past, no significant increase in productivity was achieved. Therefore, improvement programs are necessary to increase productivity and sustainable development of small ruminants in different farming systems of the country in innovative approach so as to meet the demands of the human population. Moreover, there is no or little information on the production and marketing system of sheep in Misha Woreda, Hadiya Zone, Southern Ethiopia. Therefore, it is important to assess the major sheep production system and constraints to improve the production. Therefore, the general intent of this study was to assess the production system and constraints of sheep production in the study area. Specifically, this study aims at answering the basic research questions and some other specific questions in relation to sheep production and constraints in Misha Woreda, Hadiya Zone, Southern Ethiopia.

MATERIALS AND METHODS

Description of the study area

The study was conducted in Misha Woreda, Hadiya zone which is located about 253 km away from Addis Ababa, 207 km from Hawassa and 18 km from Hossana. The Woreda is divided in to 35 Kebeles for administrative purpose. Among these, 32 Kebeles are rural and 3 Kebeles are town. Misha Woreda is bounded by Silte zone in East, Guraghe Zone in North, Gombora Woreda in South and Gibe Woreda in West direction. The altitude ranges from 1500-2900 m.a.s.l with the average temperature ranges from 18-25°C and the rainfall ranges from 1000-1500 mm. In terms of economic activities, the Woreda's community fully experienced animal rearing and crop production (mixed farming system). Misha Woreda's livestock number, cattle accounts for about 76265, 50795, 17074 and 37447 cattle, sheep, goat and poultry respectively. In addition to these, there are also transitional and modern beehives. Most dominant cereal crops found in the study area are wheat, teff, maize, sorghum, bean, pea and other cash crops like chat, coffee and vegetables are found (MWAO, 2006).

Sampling techniques and sample size

A stratified random sampling technique was used to stratify the agro-ecological zones into "Woinadega" (mid altitude), "Kola" (lowland) and "Dega" (highland). According to the district agricultural office, Misha Woreda has totally 35 Kebeles among which 17, 10, 8 Kebeles are "Woinadega" (mid altitude), "Kola" (lowland) and "Dega" (highland) respectively. For the study to make a representation based on agro-ecology, 2, 1, and 1 Kebeles were taken randomly from "Woindega", "Kola" and "Dega" respectively. From each kebele, 20 households were selected purposively based on the experience and involvement of sheep production. Thus, totally 80 households (4 Kebeles × 20 households) were included in the study to assess the sheep production, marketing system and constraints in Misha Woreda, Hadiya Zone, Southern Ethiopia.

Data collection

Both primary and secondary data were collected for the study. To collect primary data, three tools namely questionnaire, interview and group discussion were conducted. Semi-structured questionnaires were prepared and distributed for the respondents while the secondary data was gathered from written documents.

Data analysis

The collected data was analyzed and arranged by using SPSS version 16 (2007) for descriptive statistic such as mean, frequency and percentage and the results were interpreted by using tables and graphs.

RESULTS AND DISCUSSION

Socio- demographic characteristics of households

The socio-demographic characteristics of respondents in the study area is indicated in Table 1. The data showed that the majority (80%) of interviewed respondents were male headed while the remaining 20% were female headed. This suggests that sheep and goat production activities are mainly the duty of men even though they are performed by females in small amounts. According to the educational level, among the sampled respondents about 12.5% of the respondents were uneducated and the rest 87.5% were found at different stages of literacy ranging from elementary to high school grade levels. The higher proportion of the respondents (55%) is found in the age between 25 and 40 ages. However, about 30% of the respondent age is between 41 and 60 years old; whereas, about only 15% of the respondents are above

Table 1. Socio-demographic characteristics of respondents.

Variable	Categories	Numbers	%
Sex	Male	64	80
	Female	16	20
Age	25-40	44	55
	41-60	24	30
	>60	12	15
Educational status	Illiterate	10	12.5
	1-5 grade	54	67.5
	> 6 grade	16	20
Family size	1-3	4	5
	4-6	74	92.5
	>7	2	2.5

Table 2. Production system and purpose of keeping sheep and goats.

Production system	Numbers of respondents (N=80)	%
Extensive	72	90
Semi Intensive	8	10
Intensive	0	0

60 years old. With regard to family size, the majority about 92.5% of them has family size between 4 and 6 and small amount (5%) of the sampled respondents has family size between 1 and 3. However, few amount (2.5%) of the sampled respondents had a family size more than 7.

Production system and purpose of keeping sheep and goats

As indicated in Table 2, the prevailing sheep and goat production system commonly practiced in the study area is mainly extensive (90%) with slight semi-intensive characteristics (10%). Similar reports was also reported by Alemitu and Abera (2018) in the study conducted in Sodo Zuria District Wolaita Zone Southern Ethiopia where the dominant (90%) sheep production system practiced was extensive system while only 10% of the respondents practice semi-intensive sheep production system. The extensive system of sheep in the study is characterized with no or minimum inputs and improved technology which results in low productivity.

The respondents were also asked about the main purposes of rearing sheep and goats in the study area. Accordingly, about 75, 17.5 and 7.5% of the respondents keep sheep and goat for cash income, security and for slaughter during holidays. According to this finding the sampled farmers in the study area rear sheep to use for cash income dominantly (Figure 1).

Flock size sheep and goat

The flock composition of sheep and goat showed variation from farmer to farmer based on purpose of keeping and feed availability. As indicated in Figure 2, the average number of flock composition of the interviewed respondents was 5.6, 5, 5, 4, 2.9 and 2.5 for doe, ewe, lamb, buck, kid and ram. From this result, goat was the higher flock and widely reared in the area. However, the average number sheep flock composition in the study area indicates that it has a great potential as income generation, slaughter and security of the household.

Major feed sources of sheep and goats

The major feed sources of sheep and goats in the study area are indicated in Figure 3. Natural pasture with certain browse species, crop residue, improved forage and house leftover were the main feed resources of sheep and goat in the study area. Natural pasture and house leftover are main feed resources during the rainy

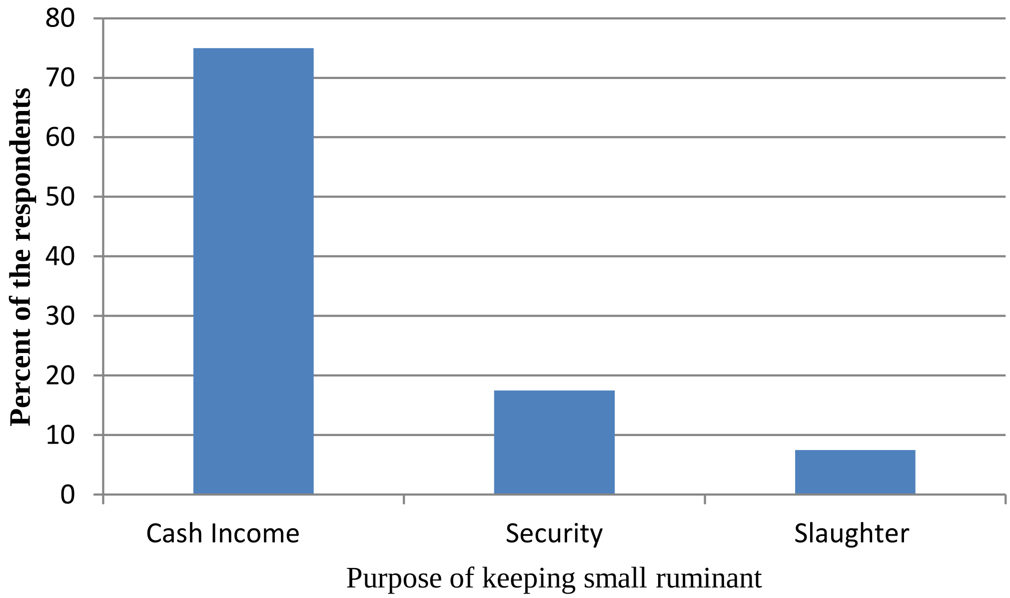

Figure 1. Purpose of keeping of small ruminants.

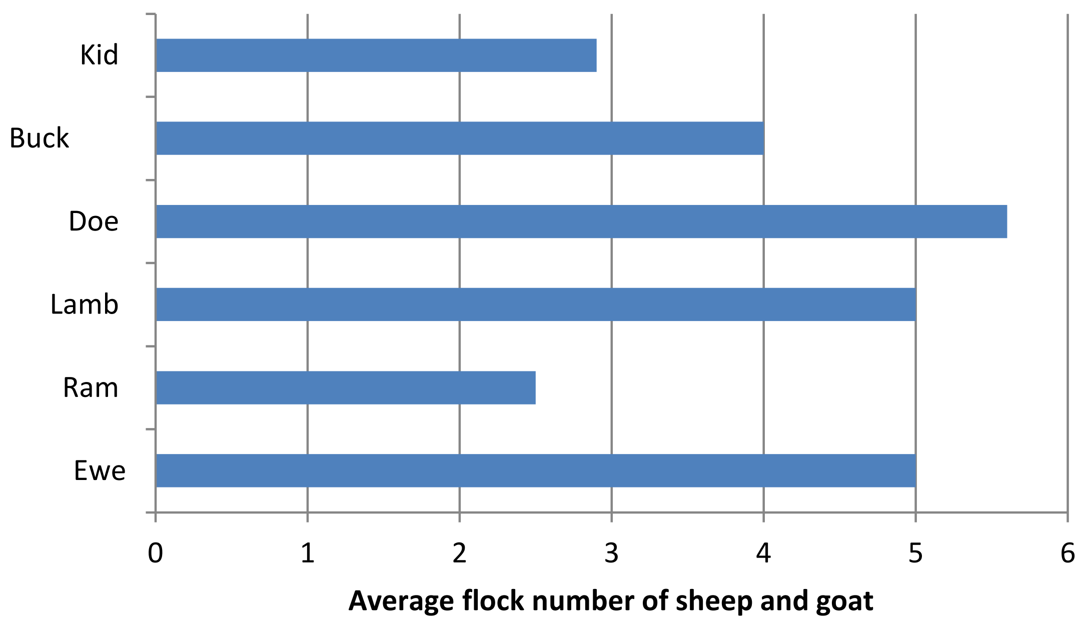

Figure 2. Flock size of sheep and goats in the study area.

season; whereas, natural pasture, crop residue, improved forage and house leftover are the feed resources in the dry season. The results showed that the main feed source (42.5%) is communal grazing land, (22.5%) house leftover and (20%) crop residues in the study area. In addition, farmers cope with the season of feed scarcity through conservation and supplementing the critical classes of the flock such as the pregnant ewes and the lambs with wheat bran, sweet potato and local brewery by-products.

Housing of sheep and goats

According to the study results, farmers used different types of houses for sheep and goats in the study area. According to data collected, the majority (81.25%) of the respondents keeps sheep and goats in the main house

Table 3. Housing type of sheep and goats in the study area.

S/N	Housing type	Frequency (N=80)	%
1	Main housing (together with family house)	65	81.25
2	Separate house	15	18.75

Table 4. Constraints of sheep and goat production in the study area.

Major constraint	Frequency	Rank
Disease band parasites	12	4
Feed shortage	44	1
Lack of capital	26	2
Shortage of land	18	3
Lack of exotic breed	9	5

together with the family in the study area except for newborn lambs and kid until weaning. About 18.75% of respondents use separate housing for newborns for a specific period of time. The respondents also indicated that barn sanitation was commonly practiced in the study area (Table 3). This finding is slightly similar with (Alemitu and Abera, 2018) who indicated that the majority (72.2%) of the respondent accommodate their flock in the main house with the family member, while 20% keep sheep together with other animals and only 7.8% have separate houses for sheep in Sodo Zuria Woreda, southern Ethiopia.

Constraints of sheep and goat production

As presented in Table 4, the most serious constraint that affects sheep and goat production which is mentioned by 44% of the respondents is feed shortage. Lack of capital was the second problem that hinders the productivity of sheep as identified by the respondents in the study area. Shortage of land diseases and parasites were the third and fourth constraints indicated by the respondents respectively. It was observed that feed shortage in the dry and rainy season, diseases, inadequate veterinary service and lack of capital are the main sheep and goat production constraints in the study area. This finding is in line with Arse et al. (2013) who indicated that the major challenges to goat production in the six selected study areas were severe feed shortage, high disease prevalence in Adami Tulu, Arsi Negelle and Fantale districts of Oromia Regional State, Ethiopia.

CONCLUSION AND RECOMMENDATIONS

The study revealed that the production system of sheep and goat is mainly extensive (90%). The extensive production system along with feed shortage needs improvement of husbandry practices. The sampled respondents used different types of houses for sheep and goats. Accordingly, about 81.25% of the respondents keep sheep and goats in the main house together with the family except for newborn lambs and kid until weaning, while about 18.75% of respondents use separate housing. Shortage of feed, shortage of grazing land and lack of capital disease and parasite are the main problems that hamper the potential of sheep and goat production in the study area. Based on the results found and the conclusions drawn, provision of training on production and husbandry practices need to be implemented; in addition to this, the extensive system of production should be improved to semi-intensive system of sheep and goat production. This finding and recommendations drawn would be used in any other situation where similar production systems are practiced.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

REFERENCES

Alemitu B, Abera A (2018). Sheep Production and Marketing System: The Case of Sodo Zuria District Wolaita Zone Southern Ethiopia. International Journal of Basic and Applied Sciences 7(2):69-74.

Arse G, Feyisa H, Gurmessa U, Merga M, Girma D (2013). Assessment on challenges and opportunities of goat farming system in Adami Tulu, ArsiNegelle and Fantale districts of Oromia Regional State, Ethiopia. African Journal of Agricultural Research 8(1):26-31.

Belete SG (2009). Production and Marketing Systems of Small Ruminants InGoma District Of Jimma Zone, Western Ethiopia M. Sc. Thesis Hawassa University, Awassa. Ethiopia.

Central Statistical Agency (CSA) (2016). Federal Democratic Republic of Ethiopia Central Statistical Agency.Agricultural Sample Survey (2012/13 [2005 E.C). Volume II, Report on Livestock and Livestock Characteristics. Statistical Bulletin 570. Addis Ababa, Ethiopia.

Kilgour R, Waterhouse T, Dwyer C, Ivanov I (2008). Farming Systems for Sheep Production and Their Effect on Welfare. In: The Welfare of Sheep. Animal Welfare, vol 6. Springer, Dordrecht.

Markos T (2006). Productivity and health of indigenous sheep breeds and crossbreds in the central Ethiopia highlands.PhD dissertation. Department of Animal Breeding and Genetics, Faculty of Veterinary Medicine and Animal Sciences, Swedish University of Agricultural Science(SLU), Uppsala, Sweden.

MWAO (2006). Misha Woreda Agricultural office Agricultural sample enumeration statistical report on agricultural products & livestock population. Misha Woreda, Hadiya Zone, southern Ethiopia.

Solomon G, Azage T, Berhanu G, Dirk Hoekstra (2010). Sheep and goat production and marketing systems in Ethiopia: Characteristics and strategies for improvement. IPMS (Improving Productivity and Market Success) of Ethiopian Farmers Project Working Paper 23. ILRI (International Livestock Research Institute), Nairobi, Kenya. 58p.

Solomon G, Van Arendonk J, Komen H, Windig J, Hanotte O (2007). Population structure, genetic variation, and morphological diversity in indigenous sheep of Ethiopia. Animal Genetics 38:621-628.

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Full Length Research Paper

Ethiopian native chicken productivity, aims of production and breeding practices across agro-climatic zones

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This study was conducted to characterize flock size, composition, productivity, motivational drivers, and breed selection criteria in village chicken production systems of lowlands, midlands, and highlands of Ethiopia. Data were collected at 360 rural households of which 120 were from lowland, 160 midland, and 80 highlands. A standardized questionnaire was used to collect the data using person to person interview method. Data were analyzed using the various statistical procedures of statistical analysis system (SAS) version 9.2. Higher flock size and productivity of chicken were obtained for midlands than the other agro-ecologies. The average flock size per household was 16.6. The average age at sexual maturity of hens was 7 months. Average number of egg production was 43 eggs per hen per year. Average hatching rate was in the range of 76 to 82%. Mortality occurred in the range of 27 to 39%. Although, village chicken has diverse use in Ethiopian rural community, the main motivations to keep village chicken were egg production followed by income generation. Eggs were mainly used for hatching, home consumption, and to generate a daily disposable income. The three most important breed selection criteria were egg production, morphometric characteristics, and mothering ability. Findings from this study can support the design of agro-ecology based breeding strategies aiming to improve native chicken production, productivity, and enhance their economic contributions to the farmers.

Key words: Ethiopian native chicken, breed selection criteria, flock productivity, motivational drivers.

INTRODUCTION

Village chickens represent the majority of poultry production in developing countries, and are mainly kept under extensive production system which is characterized by high disease and parasite infestation, predation, harsh climatic conditions, unavailability and less quality feeds, and uncontrolled breeding (Malatji et al., 2016; Jansen et al., 2009; Msoffe et al., 2009; Sekeroglu and Aksimsek, 2009; Kumaresan et al., 2008; Gondwe and Wollny, 2007).

Despite the low performances of village chickens, they

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possess several favourable characteristics which enable them to cope with the extensive form of management system. They are very well adapted to local conditions, resistant to disease, have brooding ability, and depend on scavenging for feed (Tarwireyi and Fanadzo, 2013; Harrison and Adlers, 2009; Msoffe et al., 2009; Mwale and Masika, 2009; Olwande et al., 2009; Gondwe and Wollny, 2007; Scanes, 2007; Kondombo, 2005).

Like in other African countries, the production and productivity of Ethiopian village chickens are generally low (Assefa et al., 2016; Salo et al., 2016; Getachew et al., 2015; Zewdu et al., 2013; Mekonnen et al., 2010; Aklilu et al., 2007; Halima et al., 2007a; Ashenafi et al., 2004; Tadelle, 2003; Tadelle and Ogle, 2001; Tadelle, 1996). Their average age at sexual maturity (weeks), number of eggs per hen per clutch, number of eggs per hen per year, egg weight (g) and hatching rate (%) are ranged from 26 to 28, 14 to 16, 46 to 91, 43 to 47, and 79 to 89%, respectively (Worku et al., 2012; Moges et al., 2010a; Moges et al., 2010b).

As village chickens are entirely depending on scavenging for their feed, their performances for various economically important traits could be considerably affected by agro-climatic factors. The effect of agro-climate on chicken production and productivity and farmers' management practices were previously studied in other African countries (Muchadeyi et al., 2009; Muchadeyi et al., 2007).

Although there have been few previously conducted agro-climate based chicken production system characterization studies in Ethiopia, there is still information gap in the area (Worku et al., 2012; Moges et al., 2010b). Those previously conducted studies only covered few districts in the country and few chicken production parameters.

Therefore, the objectives of this study were to characterize village chicken flock size, composition, productivity, aims of production, and breed selection criteria at national level and across major agro-climatic zones in the country. The study is expected to generate key information that can be used for developing agro-ecology based breeding strategies aiming to improve native chickens of the country.

MATERIALS AND METHODS

Study sites

In this study, nine districts were selected from four regions in Ethiopia (Oromia, Amhara, Southern Nations, Nationalities and People region (SNNP), Tigray) where village chicken production predominate, and have an easy access for transportation.

Among the nine districts, the Dodota, Haremaya and Ada districts were selected from Oromia region (3°N to 10.5°N latitude; 34°E to 43°E longitude), the Gonder Zuria and Basonaworna districts were selected from Amhara region (9° 21' to 14° 0' N latitude; 36° 20' to 40° 20' E longitude), the Arbaminch Zuria, Abeshge and Malga districts were selected from the SNNP (6°3'31.03" latitude; 36°43'38.28" longitude), and the North Mekele district was selected from Tigray region (13° 14' 06" N latitude; 38° 58' 50" E longitude).

The selected districts were categorized into three groups as lowland, midland and highlands based on their traditional form of classification which depends on altitude, temperature and rainfall. Based on this classification, lowlands were represented by the Arbaminch Zuria, Abeshge, and Dodota districts. Midlands were represented by the Ada, Gonder Zuria, Haremay and North Mekele districts, whereas, highlands were represented by the Basonaworna and Malga districts.

The lowland areas were characterized by an altitude in the range of 500 to 1,500 m.a.s.l with an annual rainfall of 200 to 800 mm, and a temperature of 20 to 27.5°C, whereas the midland areas represented an altitude in the range of 1,500 to 2,300 m.a.s.l with an annual rainfall of 800 to 1,200 mm and temperature of 17.5 to 20.0°C, which was mainly characterized by mixed crop-livestock farming.

On the other hand, highlands were featured by an altitude in the range of 2,300 to 3,200 m.a.s.l with an annual rainfall of 900 to 1,200 mm, and a temperature of 11.5 to 16.0°C. Highland districts were mainly characterized by crop production, but mixed crop-livestock farming system was also common in this area (Figure 1).

Sampling procedure

A multi-stage sampling procedure was employed to select sampling locations and target households. In each district, four villages were selected, and 10 households that had a minimum of five chickens were randomly selected in each village. In total, 360 households: 80 from highlands, 160 midlands, and 120 lowlands were considered. Person to person interview was made to collect qualitative and quantitative data on chicken flock size and composition, productivity, motivational drivers, breed selection criteria and farmers' socio-economic features using a standardized questionnaire. Data collection was supported by the technical staffs of the agricultural and rural development offices in Ethiopia. Agro-climatic data of the selected districts were obtained from the respective agricultural and developmental main offices in Ethiopia.

Statistical analyses

The data were coded and stored on a database. A generalized linear model procedure of statistical analysis system (SAS) version 9.2 (SAS Institute Inc., 1999) was used to study the effect of agro-climate on the studied parameters like chicken flock size, composition and productivity (Tables 1 and 2). The three agro-climatic zones: lowlands, midlands and highlands were considered as fixed effect in the model. Rank means were compared using a non-parametric Kruskal Wallis test (NPAR1WAY) procedure of SAS version 9.2 (SAS Institute Inc., 1999) for non-measurement variables like motivation to keep chicken and breed selection criteria (Tables 3 and 4). Alpha level of 0.05 was used to reject the null-hypothesis of no difference on the studied parameters across the three agro-climatic zones.

RESULTS AND DISCUSSION

Socio-economic features of chicken farmers

As previously reported by Goraga et al. (2016), 56.3% of the 360 respondents were males and 43.8% were females. The respondents had an average age of 38 years, and 84.9% were married. Regarding their religion, 45.9% of them were Orthodox, 22.5% were Muslim, and

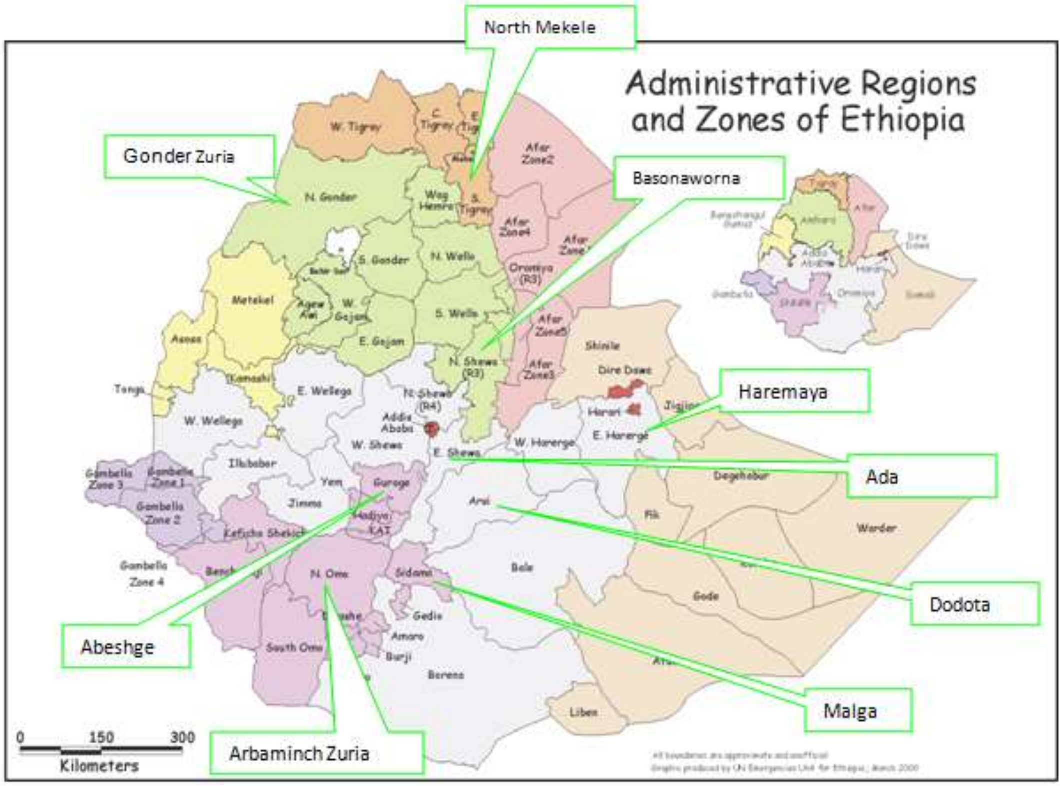

Figure 1. Sampling sites in Ethiopia. Administrative regions (small Map), zones (big Map), two city-states (red colour), and selected districts (green coloured boxes).

Table 1. LSmeans and standard errors of chicken flock size and composition by agro-climatic zone.

Parameter	**Agro-climatic zones**			**Overall means**
	Lowlands	**Midlands**	**Highlands**	
Number of households	120	160	80	-
Chicken flock size				
Chicks	5.3 (0.57)^{a}	8.5 (0.56)^{b}	4.9 (1.07)^{a}	6.2
Pullets	2.8 (0.26)^{a}	4.6 (0.23)^{b}	2.3 (0.33)^{a}	3.2
Cockerels	1.9 (0.21)^{a}	3.1 (0.17)^{b}	1.7 (0.25)^{a}	2.2
Hens	3.0 (0.22)^{a}	3.8 (0.20)^{b}	3.0 (0.26)^{a}	3.3
Cocks	1.7 (0.22)^{a}	2.3 (0.16)^{b}	1.2 (0.20)^{a}	1.7
Total	14.7 (0.91)^{b}	22.3 (0.79)^{c}	13 (1.06)^{a}	16.6

The same superscripts in rows are not significantly different (P>0.05). LSmeans refers to least square means.

17.6% were Protestant. 64.9% of the respondents were literate and 35.1% were illiterate. The average family size was composed of 6 members. The households had on average 1.7 ha of land. In lowlands, farmers had on average 0.46 and 0.20 ha more land than those living in midlands and highlands, respectively. 83.1% of the total households were engaged in farming activities. Only 16.9% were engaged in off-farming activities. Most of the households came from families who had farming background.

Flock size and composition

The average flock size per household is 16.6. The flocks were composed of 37.3, 19.3, 13.3, 20 and 10.1% chicks, pullets, cockerels, hens, and cocks, respectively (Table 1). Flock size differed (P<0.05) by agro-climatic zone.

Table 2. LSmeans and standard errors of chicken production performance by agro-climatic zone

Parameter	Agro-climatic zones			Overall means
	Lowlands	Midlands	Highlands	
Number of households	120	160	80	-
Egg production traits				
AFE (in weeks)	31.7 (0.6)[c]	24.8 (0.56)[a]	27.8 (0.77)[b]	28.1
Clutch number	2.9 (0.08)[b]	2.4 (0.07)[a]	3.2 (0.09)[c]	2.83
Eggs per clutch	14.5 (0.44)[a]	16.2 (0.39)[b]	14.4 (0.52)[a]	15
Number of eggs per year	43 (1.84)[a]	42 (1.66)[a]	45 (2.14)[a]	43
Eggs in a set	10.9 (0.28)[a]	12.2 (0.24)[b]	12.1 (0.33)[b]	11.7
Hatchability (%)	76.4 (1.28)[a]	80.2 (1.14)[b]	81.9 (1.54)[b]	79.5
Mortality (%)	39.5 (2.90)[b]	27.9 (2.56)[a]	33.4 (3.40)[ab]	33.6

The same superscripts in rows are not significantly different (P>0.05). LSmeans refers to least square means.

Table 3. Rank means and standard deviations for motivations to keep chicken (1=most important up to 5=least important).

Parameter	Agro-climatic zones			Sig[b]
	Lowlands	Midlands	Highlands	
Number of households	120	160	80	-
Motivations				
Egg	2.0 (2.03)	3.6 (2.50)	2.4 (2.2)	***
Meat	4.5 (1.92)	5.8 (0.84)	5.8 (0.83)	***
Income	3.5 (2.18)	2.4 (1.98)	3.1 (2.2)	***
Manure	5.9 (0.18)	6.0 (0.00)	5.9 (0.62)	NS
Hobby	5.9 (0.45)	5.9 (0.31)	5.9 (0.49)	NS
Sig[a]	***	***	***	-

Sig[a] refers to significance of rankmeans of motivational drivers within agro-climatic zone and **Sig**[b] significance of rankmeans across agro-climatic zones. Significant at P<0.05 (*), P<0.01 (**), and P<0.001 (***). Rank means were compared using Kruskal Wallis test.

Table 4. Rankmeans and standard deviations attached to breed selection criteria (1=most important up to 5=least important).

Parameter	Agro-climatic zones			Sigb
	Lowlands	Midlands	Highlands	
Number of households	120	160	80	-
Breed selection criteria				
Egg	3.2 (1.78)	2.5 (1.87)	4.4 (1.36)	***
Growth	3.8 (1.83)	4.2 (1.61)	5.0 (0.00)	**
Mothering ability	4.4 (1.22)	4.6 (0.95)	3.5 (1.65)	***
Disease resistance	4.4 (1.14)	4.4 (1.21)	5.0 (0.00)	*
Morphometric characteristics	4.3 (1.21)	4.2 (1.54)	1.6 (1.49)	***
Siga	*	***	***	-

Sig[a] refers to significance of rankmeans of breed selection criteria within agro-climatic zone and **Sig**[b] significance of rankmeans across agro-climatic zones. Significant at P<0.05 (*), P<0.01 (**), and P<0.001 (***). Rank means were compared using Kruskal Wallis test.

Chicken farms in midlands had higher flock size than those in lowlands and highlands. The average number of chicks, pullets, cockerels, hens, and cocks per household is not different between lowlands and highlands.

Average flock size of 12.1, 12.9 and 14.4 was previously reported in Ethiopia (Mekonnen et al., 2010), Malawi (Gondwe and Wollny, 2007), and Mozambique (Harrison and Adlers, 2009), respectively. These flock sizes were lower than the flock size of 16.6 which was obtained in the present study. However, higher flock sizes 19 and 33.5 were reported in Kenya and Burkina Faso, respectively (Olwande et al., 2009; Kondombo et al., 2003).

The flocks in the present study mainly composed of chicks and pullets in midlands and chicks in lowlands and highlands. Overall flock composition was dominated by chicks. The higher flock size obtained in midlands than the other two zones might be associated with better management and environmental conditions. Flock size and composition was different in the three agro-climatic zones.

This is in agreement with previous findings in Zimbabwe (Muchadeyi et al., 2007). The average flock size generally at African rural households is small. Lower flock size especially for hens can attribute to lower egg production at farm level.

Flock productivity

Hens reached sexual maturity on average at 7 months. They had on average 2.8 clutches per year, and laid 15 eggs per clutch. Average number of egg production was 43 eggs per hen per year (2.83 clutch number × 15 eggs per clutch). The hatchability and mortality rate are 79.5 and 33.6%, respectively. Production performance and mortality rate of rural chicken differed ($P<0.05$) in the three agro-climatic zones (Table 2).

In midlands, hens reached sexual maturity 3 and 6.9 weeks earlier than hens in highlands and lowlands, respectively. Hens in highlands had the highest clutch numbers. Hens in midlands laid on average 1.7 and 1.8 more eggs per clutch than hens in lowlands and highlands, respectively. Low hatchability (76.4%) was obtained in lowlands. Similar hatchability rates were obtained in midlands (80.2%) and highlands (81.9%). Mortality rate is the highest in lowlands (39.5%).

All egg parameters except number of eggs laid per hen per year (clutch number × eggs per clutch) differed ($P<0.05$) by agro-climatic zone. Average hens' sexual maturity obtained in the present study is 28 weeks which is in agreement with values (28 to 38 weeks) reported by Halima et al. (2007b). Hens in lowlands reached sexual maturity 6.9 and 3.9 weeks later than those in midlands and highlands, respectively.

Higher number of eggs per clutch and eggs in a set were obtained in midlands. In highlands, higher clutch number and hatchability were obtained. Hens in lowlands were characterized by late age at sexual maturity, lowest number of eggs in a set, lowest hatchability, and highest mortality.

Most of the present findings on egg parameters such as age at sexual maturity, clutch number, number of eggs per clutch, total egg production per year, hatchability, and mortality were in the range between values reported previously in Ethiopia (Halima et al., 2007a; Tadelle and Ogle, 2001). The numbers of eggs per clutch and percent hatchability obtained in this study were higher than the values reported in Burkina Faso (Kondombo et al., 2003).

Generally, the low performances of hens of rural chicken for egg production traits could be partly explained by the late age at sexual maturity and long times spent for incubating eggs and taking care of their chicks (Olwande et al., 2009). The observed differences in hens laying performance across the three agro-climatic zones might be due to the variations in resource availability, management practices, disease infestation, and climatic factors among the different zones.

Motivation to keep rural chicken

Farmers ranked the motivations to keep chicken from most important (1) to least important (6). In lowlands, the motivations to keep chicken are mainly attached to egg production (2.0±2.03) and income generation (3.5±2.18).

In midlands, farmers keep chicken mainly for income generation (2.4±1.98) and egg production (3.6±2.50). The motivations to keep chicken in highlands were similar to the motivations in lowlands. Generally, rural farmers in Ethiopia keep chicken mainly for egg production (2.7±2.2). The eggs are used for hatching, home consumption, and generation of a daily disposable income. The observed motivational drivers in village chicken production are different both within and between agro-climatic zones (Table 3).

The aims of production at rural chicken farms might differ among countries and across agro-ecological zones within a country (Jansen et al., 2009; Muchadeyi et al., 2007; Henning et al., 2006). In the present study, similar situation was observed, that is, the motivations to keep chicken differed among the three agro-climatic zones. In lowlands, the motivations to keep chicken were mainly attached to egg production (1st) and income generation (2nd). In midlands, farmers keep chicken mainly for income generation (1st) and egg production (2nd). The motivations to keep chicken in highlands are similar to the motivations in lowlands.

Data analysis using the whole data set (360 households) revealed that Ethiopian rural farmers keep chicken primarily for egg production which is the basis for hatching, home consumption, and generating a small daily disposable income. About 23% of eggs produced at rural household go to the market (Tadelle and Ogle,

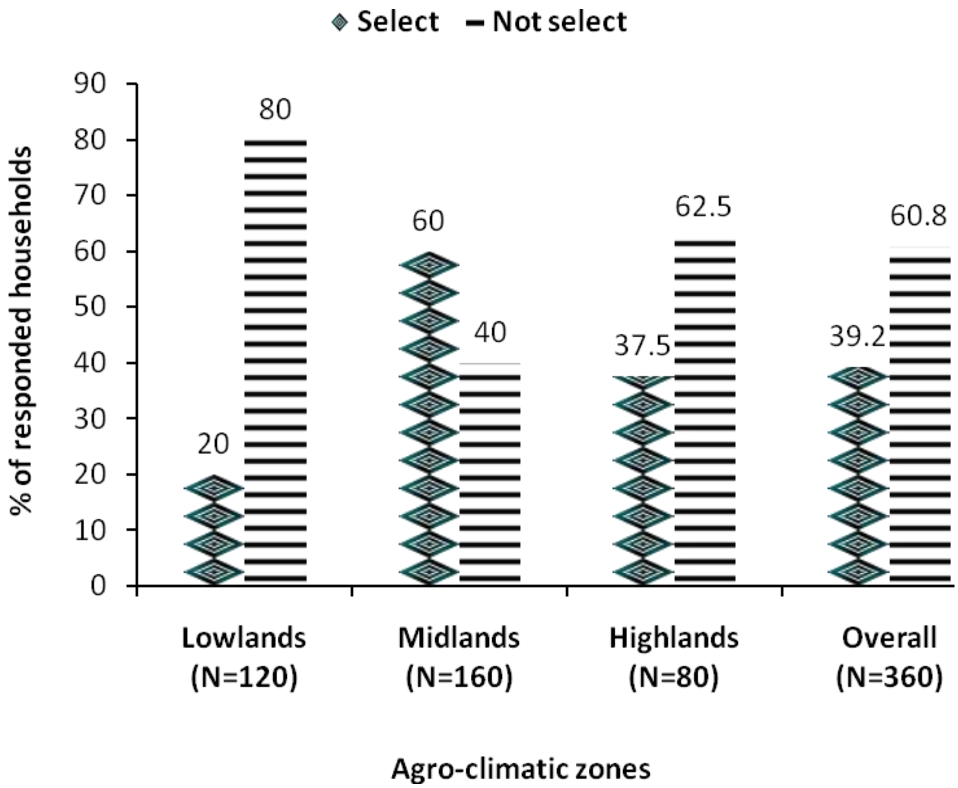

Figure 2. Percentage of village chicken producing households selecting or not selecting parents and/ or breeds for breeding purpose.

2001). Unlike in Ethiopia, meat production was reported as the chief role of chicken to the households in South Africa (Mwale and Masika, 2009).

Breed selection criteria

Breed selection criteria are egg production, growth performance, mothering ability, disease resistance and morphometric characteristics. About 60.2% of the 360 households did not select chicken for breeding purpose (Figure 2). Only 39.8% of the households selected chicken for breeding based on one or more specific criteria.

The farmers ranked the aforementioned five breed selection criteria from most important (1) to least important (5). The criteria of breed selection are different in the three agro-climatic zones. Egg production (number and weight of eggs) as breed selection criteria is the most important in midlands (2.5±1.87) and lowlands (3.2±1.78). Mothering ability and morphometric characteristics are the most important in highlands. Breed selection criteria differed ($P<0.05$) also within agro-climatic zone.

For instance, in lowlands, egg productions followed by growth are the most important breed selection criteria. In midlands, selection is mainly depended on egg production (2.5±1.87). Morphometric characteristics (e.g. plumage colour) followed by mothering ability (e.g. aggressiveness to predator, ability to hatch more eggs) are the most important breed selection criteria in highlands (Table 4).

This study shows that not many of the Ethiopian rural households do practice breed selection and this is in agreement with previous findings in other African countries (Olwande et al., 2009; Kondombo, 2005). Only 39.8% of all households select parents for breeding based on laying performance, morphometric characteristics (for example, plumage colour) and mothering ability (for example, aggressiveness against predators, ability for hatching). Differences in criteria of breed selection were observed both within and among agro-climatic zones, which is in agreement with the findings of Muchadeyi et al. (2009). Laying performance as the most important selection criteria agrees with the aim of production at farm level. Traits such as productivity, size of the eggs, broodiness, and alertness were previously mentioned as selection criteria (Tadelle, 2003).

Farmers in Zimbabwe choose breeding animals primarily based on body size followed by mothering ability, fertility, and morphological traits (Muchadeyi et al., 2009). Even if some farmers keep parents as a breeding stock, mating is uncontrolled as rural chicken spent their days in the field together with other flocks coming from

Figure 3. A typical free range layers production system practiced in Brazil. The chicken presented in this picture represent tropically adapted breed called Embrapa 051.

the nearby households. None of the households participated in this study practiced record keeping, which is in agreement with previous findings in other African countries (Muchadeyi et al., 2009).

Therefore, farmers select the best breeding stocks simply based on daily observation of the hens' performance. The disadvantage of this practice is that one cannot easily follow the pedigree information as there is no record keeping. In addition, it is difficult to remember the long term production performance of hens.

Conclusions

Like in other African countries, the Ethiopian village chicken production systems are characterized by small flock size and diverse flock composition where chicks account for the highest percentage of the flock size per farm. This study reveals that the production performances of Ethiopian village chicken are low. However, in most cases, the performances are comparable to the performances of native chicken kept in other African countries.

Agro-climate did affect many of the studied economically important traits such as age at sexual maturity, number of clutches per hen per year, number of eggs per clutch per hen, and hatching and mortality rates. Thus, it is very important to consider agro-ecological variations in any research interventions aiming to improve or evaluate the native chicken breeds kept in an extensive production system.

This study further reveals that egg production and income generation are the most important motivational drivers for keeping native chicken at Ethiopian smallholder farmers' level. For this reason, the majority of the interviewed farmers did select their parental stocks mainly based on egg production performance followed by mothering ability and morphometric characteristics.

Despite the low performance of Ethiopian village chicken, their adaptability to low input and harsh environment conditions in an extensive chicken production systems need to be appreciated, and mechanisms need to be designed to improve the existing village chicken production systems both in terms of size of production and flocks' productivity. Alternatively, various model poultry production systems can be adopted from foreign countries to improve Ethiopian chicken production systems. A typical example can be introducing "a free range layers production system of Brazil (Figure 3)" where smallholder farmers can keep thousands of layers per small pieces of land and can collect several hundreds to thousands of eggs per day.

A free range layers production system can quickly ensure food security, generate huge daily income and improve livelihoods. Furthermore, the system can help to quickly satisfy the country's egg demand. In this system, farmers are expected to practice "all-in and all-out system" and start the production with three months old pullets and keep the flocks until culling age which is usually after two years of egg production. Implementation of improved free range layers production system requires a package composed of tropically adapted chicken breed (for example, Embrapa 051 or Bovan Brown), 600 to 800 m^2 of land, commercial feed, simple house which can be constructed with local materials, and fence for covering the scavenging field.

Therefore, model free range chicken production systems with tropically adapted and high egg yielding or dual purpose chicken breeds need to be promoted in order to transform the existing small flock sizes and low performances in Ethiopia.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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REFERENCES

Assefa H, Bogale A, Gebremedhin B, Mekuriaw Z, Derso T, Dessalegn Y, Tegegne A, Hoekstra D (2016). "Village Chicken Production and Marketing in West Gojjam Zone, Ethiopia. Current Research on Agricultural Science 3(4):64-73.

Getachew T, Ewonetu K, Negassi A, Aemro TT (2015). Village Chicken Husbandry Practice, Marketing and Constraints in Eastern Ethiopia. Journal of World's Poultry Ressearch 5(4):104-108.

Gondwe TN, Wollny CBA (2007). Local chicken production system in Malawi: Household, flock structure, dynamics, management and health. Tropical Animal Health Production 39:103-113.

Goraga Z, Luizinho C, Cassio W, Gudrun AB (2016). Characterization of village chicken production systems and challenges across agro-climatic zones in Ethiopia. International Journal of Livestock Production 7(11):94-105.

Halima H, Neser FWC, Marle-Koster EV, Kock D (2007a). Village-based indigenous chicken production system in north-west Ethiopia. Tropical Animal Health Production 39:189-197.

Halima H, Neser FWC, Marle-Koster EV, Kock AD (2007b). Phenotypic variation of native chicken populations in northwest Ethiopia. Tropical Animal Health Production 39:507-513.

Harrison JL, Alders RG (2009). An assessment of chicken husbandry including Newcastle disease control in rural areas of Chibuto, Mozambique. Tropical Animal Health Production. DOI 10.1007/s11250-009-9480-y.

Henning J, Khin A, Hla T, Meers J (2006). Husbandry and trade of indigenous chicken in Myanmar-Results of a participatory rural appraisal in the Yangon and the Mandalay divisions. Tropical Animal Health Production, 38:611-618.

Jansen T, Glatz PC, Miao ZH (2009). A survey of village poultry production in the Solomon Islands. Tropical Animal Health Production 41:1363-1370.

Kondombo SR (2005). Improvement of village chicken production in a mixed (chicken-ram) farming system in Burkina Faso. PhD Thesis, Wageningen Institute of Animal Sciences, Animal Nutrition Group, Wageningen University, P.O. Box 338, 6700 AH Wageningen, The Netherlands, 1-200.

Kondombo SR, Nianogo AJ, Kwakkel RP, Udo HMY, Slingerland M (2003). Comparative analyses of Village Chicken Production in Two Farming Systems in Burkina Faso. Tropical Animal Health Production 35:563-574.

Malatji DP, Tsotetsi AM, Van Marle-Koster E, Muchadeyi FC (2016). A description of village chicken production systems and prevalence of gastrointestinal parasites: Case studies in Limpopo and KwaZulu-Natal provinces of South Africa. Onderstepoort Journal of Veterinary Research 83(1):968.

Mekonnen H, Mulatu D, Kelay B, Berhan T (2010). Assessment of the nutritional status of indigenous scavenging chicken in Ada'a district, Ethiopia. Tropical Animal Health Production 42:123-130.

Moges F, Azage T, Tadelle D (2010a). Indigenous chicken production and marketing systems in Ethiopia: Characteristics and opportunities for market-oriented development. IPMS (Improving Productivity and Market Success) of Ethiopian Farmers Project Working Paper 24. Nairobi, Kenya, ILRI.

Moges F, Abera M, Tadelle D (2010b). Assessment of village chicken production system and evaluation of the productive and reproductive performance of local chicken ecotype in Bure district, North west Ethiopia. African Journal of Agricultural Research 5(13):1739-1748.

Muchadeyi FC, Wollny CBA, Eding H, Weigend S, Makuza SM, Simianer H (2007). Variation in village chicken production systems among agro-climatic zones of Zimbabwe. Tropical Animal Health Production, 39:453-461.

Muchadeyi FC, Wollny CBA, Eding H, Weigend S, Simianer H (2009). Choice of breeding stock, preference of production traits and culling criteria of village chicken among Zimbabwe agro-climatic zones. Tropical Animal Health Production 41:403-412.

Mwale M, Masika PJ (2009). Ethno-veterinary control of parasites, management and role of village chicken in rural households of Centane district in the Eastern Cape, South Africa. Tropical Animal Health Production 41:1685-1693.

Olwande PO, Ogara WO, Okuthe SO, Muchemi G, Okoth E, Odindo MO, Adhiambo RF (2009). Assessing the productivity of indigenous chicken in an extensive management system in southern Nyanza, Kenya. Tropical Animal Health Production, DOI 10.1007/s11250-009-9418-4.

Salo S, Tadesse G, Hilemeskel D (2016). Village Chicken Production System and Constraints in Lemo District, Hadiya Zone, Ethiopia. Poultry, Fisheries and Wildlife Sciences, 4:158. doi:10.4172/2375-446X.1000158.

SAS Institute, Inc (1999). SAS OnlineDoc®, Version 8. SAS Institute, Inc, Cary, NC. P 1176.

Scanes CG (2007) Contribution of Poultry to Quality of Life and Economic Development in the Developing World. Poultry Science 86:2289.

Tadelle D, Ogle B (2001). Village Poultry Production Systems in the Centeral Highlands of Ethiopia. Tropical Animal Health Production 33:521-537.

Tadelle D (2003). Phenotypic and genetic characterization of local chicken ecotypes in Ethiopia. Ph.D. thesis. Humboldt University of Berlin, Germany.

Tadelle D (1996). Studies on village poultry production in the Central Highlands of Ethiopia. MSc. Thesis, Swedish University of Agricultural Science, Uppsala, Sweden.

Tarwireyi L, Fanadzo M (2013). Production of indigenous chickens for household food security in rural KwaZulu-Natal, South Africa: A situation analysis. African Journal of Agricultural Research 8(46):5832-5840.

Worku Z, Melesse A, Giorgis TY (2012). Assessment of Village Chicken Production System and the Performance of Local Chicken Populations in West Amhara Region of Ethiopia. Journal of Animal Production 2(4):199-207.

Zewdu S, Binyam K, Bilatu A, Ferede A (2013). Village chicken production systems in Metekel zone, Northwest Ethiopia. Wudpecker Journal of Agricultural Research 2(9):256-262.

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Full Length Research Paper

Determination of bee spacing and comb cell dimensions for Apis mellifera Scutellata honeybee race in western Ethiopia

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A study was conducted at Assosa and Mao-komo districts of Benishangul-gumuz regional state, western Ethiopia, aiming to determine the bee spacing and cell dimensions of honeybee race Apis mellifera scutellata. The measurement of bee spacing and cell dimensions were taken from 20 traditional hives at each agro-ecology. Assosa and Mao-komo districts were purposively selected to represent mid-altitude and highland agro-ecologies respectively. Data collected were analyzed in descriptive statistics, t-test, correlation and General Linear Model (GLM) procedures using statistical package for social sciences (SPSS) computer software. The present results revealed that bee space in naturally built combs of A. mellifera scutellata honeybee race in highland areas was significantly higher (P < 0.001) than that of mid-altitude areas. Cell depths and comb thickness were significantly different (P < 0.001) between the agro-ecologies. Larger cell depth and comb thickness were recorded in combs from mid-altitude than highland areas. On the contrary, cell diameter of naturally built combs in mid-altitude was significantly lower (P < 0.001) than cell diameter in highland areas. Type of comb did not affect the bee space, comb thickness or cell dimensions. Dimensions of traditional hives were not different between the two agro-ecologies except hive length. Traditional hives in highland areas were significantly longer (P < 0.05) than hives in mid-altitude areas. In conclusion, there were variations in bee space and comb cell dimensions within the same honeybees race in different agro-ecologies but this needs designing of new casting molds and box hives pertinent to the agro-ecologies.

Key words: Benishangul-gumuz, cell diameter, comb thickness, hive dimension, natural combs.

INTRODUCTION

Ethiopia has a wide range of topography, climate and vegetation, which favors considerable number of honeybee colonies and a diversity of honeybee races (Gebreyesus, 1976). This makes the country one of the ten major honey producing countries in the world. According to the relatively recent findings on morph-clusters of geographical races of honeybees in Ethiopia, five honeybee races exist in different agro-ecological zones of the country (Amsalu, 2002; Nuru, 2002). These races include *Apis mellifera bandasii, Apis mellifera*

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jementica, *Apis mellifera monticola*, *Apis mellifera scutellata* and *Apis mellifera woyi-gambella*.

Bee space is a path or corridor which bees need to move between combs and around the nest in the wild. It is important to allow bees walk freely on the comb (Jones, 1997, 1999). In frame hives, bee space is needed between the outside end of each frame and inner hive wall opposite it, between opposite surface of completed and sealed worker brood combs, and between the top of frames in the lower box and the bottom of the frames in the upper box (Crane, 1990). This bee space varies between 6 and 10 mm for the honeybee races, depending on their body sizes. Wild bees start the comb construction from one point and develop other combs on each side at equal distance leaving equal gap (that is, bee space) between each comb (Jones, 1999).

Similarly, the comb spacing and cell dimension have been pre-determined by the body size of the bee workers in the particular races. This should be the same as the centre-to-centre distance between adjacent combs and depth and diameter of comb cells built by similar bee races in the wild nest. If too small spacing is used, bees cannot rear brood on both sides of the combs, if the spacing is too large, they are forced to build “burr or bracing” comb in over large gaps between combs (Crane, 1999; Jones, 1999).

According to Crane (1990), comb spacing is different for various honeybee races depending on the body size of the workers. For examples, the comb spacing for the most European honeybee races is about 35 mm (32 to 38 mm), while about 32 mm (30 to 34 mm) for most African honeybee races. However, honeybees tolerate certain bee space and comb cell dimensions in the honey chamber. Thus, workers' cell dimensions are important factors for determining the bee space and comb spacing of a race.

Therefore, bee space is what dictates the distance at which the beekeepers space the frames in the modern-box hives and the bars in top-bar hives. Information on nest volume, bee spaces and dimensions of brood cells are important factors for developing and adapting movable frame hives appropriate to biology of any honeybee race (Nuru et al., 2016). Any variation inside measurements of a hive from the standards will result in incorrect bee spaces, which will cause considerable trouble during colony manipulation (Morse and Hooper, 1985). For making any type of frame or bar hives and casting mould, it is important to make sure that correct bee space and comb cell dimensions are maintained to make the hive operation more efficient.

To the best of our knowledge, the appropriate bee space and comb cell dimensions in the wild nest (traditional hives) and the tolerable frame space in modern hives are not yet studied for the local honeybee races in Ethiopia. So, determination of natural bee space and comb cell dimensions for each race in the country is important to get the correct tolerable bee space. Moreover, no standardized hive and casting mould design have been made in the country so far. The construction of hives in Ethiopia is simply made by adoption of European dimensions that is not comparable with the size of local bees, as a result so many problems have been observed during hive manipulations. Therefore, objective of the present study was to determine the bee space and comb cell dimensions for Ethiopian honeybee race, *Apis mellifera scutellata*.

MATERIALS AND METHODS

Study area

This study was conducted in two districts of Benishangul-gumuz regional state, namely Assosa and Mao-komo. Mao-komo represents highland and Assosa midland agro-ecologies of the region. Assosa town is located 670 km west of Addis Ababa. Mao-komo is located about 105 km south of Assosa town. Benishangul-gumuz regional state is located between geographical coordinates: 9°30'N-11°39'N latitude and 34°20'E to 36°30' E longitude with altitude ranging from 1272 to 1573 m above sea level. Mean annual rainfall in the region ranges from 700 to 1450 mm and temperature from 21 to 35°C (AMS, 2008). Major crops grown in the areas are sorghum, maize, finger millet, soya bean and ground nut. Livestock species commonly kept are goats, cattle, chicken and donkeys in order of importance (AsARC, 2006).

Sampling method

The two districts (Assosa and Mao-komo) were selected purposively based on their agro-ecology. Four peasant associations (PAs) were selected randomly from each district and then five beekeepers from each PA based on merit of having traditional hive. Thus, a total of 40 colonies (one colony per household) were purchased for data collection. Colonies had a similar age of 1 year. The traditional hives were made of bamboo and grass.

Sources and methods of data collection

Bee space

The average natural bee space of *A. mellifera scutallata* was measured as the distance between two adjacent opposite combs in naturally built combs in traditional hives. Both honey and brood combs were considered while sampling for measurement. Accordingly, 20 traditional hives were used per agro-ecology. For each traditional hive, 3 bee spaces at different points in the hive were measured to yield a total of 120 measurements.

Cell dimensions: Brood and honey combs were obtained from 20 colonies in each agro-ecology, and the average depth and width of comb cells was determined. For each colony, the depth and width of 5 cells were measured giving a total of 200 measurements. The measurements were taken in millimetres using calliper to 0.1 mm accuracy.

Comb thickness: Comb thickness was measured for both brood and honey combs collected from 20 traditional hives from each agro-ecology. Combs used for measurements were completed and sealed. Five measurements were done for each colony giving a total of 200 measurements for each comb type.

Table 1. Bee space, cell dimensions and thickness from naturally built honey and brood combs of *A. mellifera scutallata* in two agro ecologies of Benishangul-gumuz region.

Parameters	Agro-ecology	Mid-altitude mean		Highland mean (SE)		SE	P_{AE}	P_{CT}	P_{AExCT}
	Comb type	Honey	Brood	Honey	Brood				
Bee space (mm)		10.4	10.9	20.4	19.6	0.96	***	ns	ns
Cell depth (mm)		11.4	10.8	9.6	9.5	0.27	***	ns	ns
Cell diameter (mm)		2.4	2.5	4.3	4.1	0.20	***	ns	ns
Comb thickness (mm)		22.7	21.5	19.0	19.0	0.53	***	ns	ns

***significant at 1%, PAE effet of agro-ecology, PCT effect of comb types , PAExCT interactioneffect of agro-ecology and comb types.

Hive dimensions: Length, width and height of 20 traditional hives made of locally available materials were measured in each agro-ecology.

Data analysis

Data were entered into statistical package for social sciences (SPSS) computer software and the appropriate data management techniques were applied prior to data analysis. Independent two sample *t*-Test was used to compare hive dimensions in two agro-ecologies. Correlation analysis was done to determine the degree of relationship of variables. Agro-ecology (mid-altitude and highland), comb type (honey and brood) and their interactions were used as fixed factors for the dependent variables using General Linear Model Procedures. The model was $Yijk = \mu + Ai + Cj + ACij + \varepsilon ijk$, where $Yijk$ is dependent variable, μ is the overall mean, A_i is the fixed effect of agro-ecology i, i= mid-altitude, highland; C_j is the fixed effect of comb type j, j= honey comb, brood comb; AC_{ij} is the interaction of agro-ecology and comb type and ε_{ijk} is the random error.

RESULTS

Bee space, cell dimensions and comb thickness

Bee space, cell dimensions and thickness from naturally built honey and brood combs of *A. mellifera scutellata* race in mid-altitude and highland areas of Benishangul-gumuz Regional state of Ethiopia is presented in Table 1. Bee space was significantly different (P<0.001) between the two agro-ecologies, but not significantly different (P>0.05) between comb types. The interaction of agro-ecology and comb type was also not significant (P>0.05). Bee space of naturally built combs in highland was considerably larger than combs in mid-altitude areas. Cell dimensions and comb thickness were also significantly different (P<0.001) between the agro-ecologies, but not between comb types. Honeybee race of *A. mellifera scutellata* in mid-altitude built combs with larger cell depth than highland areas. However, cell diameter of naturally built combs was remarkably higher (P<0.001) in highland than mid-altitude. Comb thickness was significantly higher (P<0.001) in mid-altitude than highland. The average bee space in mid-altitude and highland areas in naturally built combs for *A. mellifera scutallata* were 10.66 and 20.03 mm, respectively, regardless the comb types. The average cell depths in mid-altitude and highland areas were 11.05 and 9.53 mm, respectively. In the same manner, cell diameters in mid-altitude and highland areas were 2.46 and 4.20 mm, respectively; and the average comb thicknesses in mid-altitude and highland areas were 22.10 and 19.01 mm, respectively.

Hive dimensions

Dimensions of the traditional hives made of locally available materials, like bamboo and grass in the study areas is presented in Table 2. Traditional hives were significantly different in length (P<0.05) between mid-altitude and highland agro-ecologies of the study area; otherwise they were similar in terms of width and height. Hives used in highland areas were markedly longer than that of hives used in mid-altitude areas.

Correlations among bee space and cell dimensions

The correlation analysis among bee space and cell dimensions is indicated in Table 3. All variables were significantly (P<0.001) correlated each other. The bee space was negatively correlated with cell depth and comb thickness but positively correlated with cell diameter. Cell depth was negatively correlated with cell diameter, but positively correlated with cell thickness. Comb thickness was negatively correlated with cell diameter.

DISCUSSION

Bee spaces and the dimensions of brood cells vary among honey bee races (crane, 1990; Nuru et al., 2016). In this study, however, bee space, cell dimension and comb thickness of naturally built combs varied across agro-ecologies within the same honeybee race of *A. mellifera scutallata* in western Ethiopia. As reported by Endale et al. (2015), the agro-ecology had a significant effect on bee space and cell dimensions within the same

Table 2. Dimensions of traditional hives in two agro-ecologies of the study area (N=70).

Parameter (cm)	Mid-altitude		Highland		T	P-value
	Mean	SE	Mean	SE		
Hive length	64.07	0.65	66.31	0.55	-2.422	0.016
Hive width	28.71	0.36	28.83	0.50	-0.150	0.881
Hive height	29.28	0.42	30.46	0.53	-1.421	0.157

Table 3. Correlations among bee space and cell dimensions.

Variable	Bee space	Cell depth	Cell diameter
Bee space	-	-	-
Cell depth	-0.441***	-	-
Cell diameter	0.724***	-0.424***	-
Comb thickness	-0.447***	0.997***	-0.431***

honeybee race in South Western part of Ethiopia.

In the current study, bee space in mid-altitude was nearly within a recommended bee space range (between 6.5 to 10 mm) (Curtis, 1982), but in highland areas it was found to be over this range. The higher bee space in highland areas could be associated with the higher size of honeybees as they need more space to move freely compared to honeybees with smaller body size. However, it was unclear in this study why honeybees in highland areas use double bee space than honeybees in mid-altitude areas. This implies the importance of considering honeybee race as well as agro-ecology in terms of bee space while constructing modern box hives. This finding is important since Teffera and Selassie (2011) reported that the inappropriate bee space reduces honey production in box hives.

The average cell depths in mid-altitude and highland of study areas (11.05 and 9.53 mm, respectively) were comparable to *A. mellifera* races, 11 mm (Seeley and Morse, 1976). The average cell diameter in highland areas of the study area (4.20 mm) was comparable to other *A. mellifera* races of Africanized bees (4.84 mm) (Piccirillo and De Jong, 2003) and European *Apis meliffera* races (5.2 mm) (Steeley and Morse, 1976). However, the average cell diameter recorded from mid-altitude in the present investigation (2.46 mm) was shorter than the previously reported findings (Steeley and Morse, 1976; Piccirillo and De Jong, 2003; Nuru et al., 2016).

The longer cell diameters of combs in highland areas could be associated with larger body size of honey bees. This implies that importance of designing new wax mold as currently used wax sheet maker has a diameter of 5.4-5.5 mm which is opt for temperate bees (David, 2007). The mismatch between natural cell diameter and wax molds could be a reason for higher absconding rate of *A. mellifera scutallata* race in Benishangul-gumuz region of Ethiopia (Alemayehu et al., 2015). Also, Nuru et al. (2016) indicated that the low success rate of box beekeeping in Africa and Asia is associated with direct use of technology designed for temperate bees without considering the biology of the target races.

In present study, comb thickness in mid-altitude areas was larger than that of highland areas. Abera and Kassa (2016) and Endale et al. (2015) also reported that agro-ecology had effect on thickness of naturally built combs. The difference in comb thickness between the agro-ecologies could be associated with availability of honey in the combs as David (2007) reported that in a strong nectar flow season, honey cells are lengthened resulting in thicker combs.

Conclusions

This study highlighted the presence of variations in natural bee space and cell size within the same honeybee race at different agro-ecology in Benishangul-Gumuz region of Ethiopia. Thus, considering the natural bee space is important while constructing box hive and it would be worthy to use casting molds with a suitable cell size that matches with honeybees' natural cell size. However, further studies should be done to quantify the performance of honeybees in box hive designed based on their natural bee space and comb cell size.

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CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

REFERENCES

Abera H, Kassa B (2016). Determination of Bee Space and Cell Dimensions for Jimma Zone Honeybee Eco-Races (*Apis Malifera*), Southwest Ethiopian. Journal of Biology, Agriculture and Healthcare 6(9):41-46.

Alemayehu A, Yilma T, Yohannes E, Mulisa F, Habtamu A (2015). Analysis of honey production systems in three agro-ecologies of Benishangul-Gumuz, Western Ethiopia. Journal of Agricultural Extension and Rural Development 8(3):29-38.

Amsalu B (2002). Multivariate morphometric analysis and behavior of honeybees (*Apis mellifera* L.) in southern region of Ethiopia. PhD dissertation, Rhodes University, South Africa.

Crane E (1999). The World History of Beekeeping and Honey Hunting. Routledge, New York.

Crane E (1990). Bees and beekeeping. Science, practice and World Resources; Heinemann Newness, Professional Publishing Ltd, Haller court, Jordan Hill.

Curtis G (1982). Small Scale Beekeeping. Peace Corps, Washington, DC. Information Collection and Exchange Div Manual.

David H (2007). Natürliche Zellgröße by Eric Zeissloff. Journal Apicole Luxembourgeois.

Endale YDT, Gezahegn M, Samuel S (2015). Determination of bee spacing and comb cell dimension in traditional hive at different agro-ecologies in south western parts of Ethiopia. Journal of Agricultural Science and Research 2:29-34.

Gebreyesus M (1976). Practical aspects of bee management in Ethiopia. Proceedings of the first international conference on apiculture in tropical climates, London UK pp. 69-78.

Jones R (1997). The management of African Honeybees including the design of low Cost hives. IBRA: UK.

Jones R (1999). Beekeeping as a Business. International Bee Research Association, Published by Commonwealth Secretariat, London.

Morse R, Hooper T (1985). The Illustrated Encyclopedia of beekeeping butler and Tanner Ltd, Frame, Somerser, UK. pp. 45-46, 172-178.

Nuru A (2002). Geographical races of honeybees (*Apis mellifera* L.) of the northern regions of Ethiopia. PhD dissertation, Rhodes University, South Africa.

Nuru A, Al-Ghamdi A, Shenkute G, Mohammed A, Mohammed J, Ansari RS, Sarah E (2016). Pollination ecology, nectar secretion dynamics, and honey production potentials of Acacia ehrenbergiana (Hayne) and Acacia tortilis (Forsk.) Hayne, *Leguminosae (Mimosoideae)*, in an arid region of Saudi Arabi. Tropical Ecology 57(3):429-444.

Piccirillo GA, De J (2003). The influence of brood comb cell size on the reproductive behavior of ectoparasitic mite varroa destructor in Africanized honeybee colonies. Journal of Genetics and Molecular Research 2(1):36-42.

Seeley TD, Morse RA (2003). The nest volume of honeybee (*Apis mellifera* L.) Insects Sociaux 23(4):495-512.

Teffera A, Selassie SG (2011). On-farm evaluation of bee space of langstroth beehive. Livestock Research for Rural Development 23(207). Retrieved from http://www.lrrd.org/lrrd23/10/teff23207.htm

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Potential risk factors associated with carcass contamination in slaughterhouse operations and hygiene in Oyo state, Nigeria

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Avoiding meat contamination at slaughterhouses is crucial for food safety; consumers' awareness and concern for the type of food they eat has attracted global attention and redirected research interests towards food safety. The practical hygiene in the slaughterhouse operations play key role in the safety and wholesomeness of meat. A cross sectional survey was carried out on 60 slaughterhouses in Ibadan, Oyo and Ogbomosho, in Oyo State, South Western Nigeria. A well-structured pre-tested checklist was administered and scored; data collected were subjected to descriptive statistics and t-test to separate significant differences between abattoirs and slaughter slabs. This study revealed that for the 50 items scored, only four [environmental cleanliness (66.7%), washing of slaughtering tools and equipments (60%), access to facility to wash hands and shoes (71.7%), and appropriateness of slaughterhouse location (58.3%)] were partially observed. The remaining 46 are non-existent or poorly implemented. However, only 9 out of the 23 items of the practical hygiene and level of cleanliness compared between the surveyed abattoirs and slaughter slabs, showed significant ($p < 0.05$) differences. These are garbage disposal ($p<0.001$), washing of slaughtering tools and equipments ($p<0.001$), disinfection of the slaughterhouse ($p<0.014$), disinfection of premises ($p<0.001$), and disinfection of infrastructure and equipments ($p<0.002$). Others are, availability of sufficient and clean water ($p<0.001$), good hygiene ($p<0.033$) and also, hands washing after slaughtering ($p<0.001$) and hands disinfection ($p<0.001$). The surveyed abattoirs performed better than slaughter slabs in hygiene and level of cleanliness. But nevertheless all evidences of unhygienic practices and predisposing risk factors across the surveyed slaughter locations would serve as critical points for the distribution of contaminated meat to the public, and also serve as medium for occupational disease acquisition. Hence the issue of food safety is called to question. There is the need for workers training on operational hygiene and occupational zoonoses.

Key words: Contamination, meat hygiene, risk factors, slaughterhouse.

INTRODUCTION

Meat contamination results more often than not during meat slaughtering and processing at the slaughterhouse, causing food poisoning or food-borne diseases and thus precipitating a food safety issue (FAO, 2015; Bakhtiary et al., 2016). Food and meat poisoning are acute food-borne disease caused by contamination and have been common occurrences and a worldwide public health concern (Malangu, 2016). This global burden of food-borne diseases predominate in the developing countries (Africa and South East Asia), and has been shown to cause a high percentage of illnesses in humans and a resultant 421,000 deaths per annum globally (Malangu, 2016; WHO, 2015).

Food poisoning, meat contamination and food safety have become areas of interest and have attracted global attention due to consumers' awareness and concern for the type of meat and food which they eat (FAO, 2015). This has re-directed research interest thereby shifting grounds towards food safety and hence has attracted substantial funding and research grants to third world countries for research in food safety, zoonoses and one's health (Grace, 2015; Bardosh et al., 2017). Contamination at the slaughterhouse and contamination of meat occurs because of inadequate hygienic conditions and handling, and may be as a result of the consequence of contaminated air in form of bioaerosol which is loaded with common microbial contaminants like Salmonella, Escherichia, Clostridium (Lues et al., 2007); causing contamination of the carcass/meat, the working surfaces and equipments used in the processing (Bakhtiary et al., 2016).

Contamination is established from the attachment properties and the biofilm formation of microbes on working surfaces to facilitate cross-contamination (Koo et al., 2013; Schlegelova et al., 2004). Also, the major challenges of handling animal by-products, waste products and slaughterhouse effluents have been implicated in environmental pollution of sources of water around slaughterhouses (Koo et al., 2013). The polluted water, whose quality has been compromised, will ultimately contaminate carcass/meat during processing (Adeyemo, 2002; Cook et al., 2017). Previous studies in Nigeria, published between 2001 and 2016 have shown that contamination of carcass/meat at the abattoirs constitute 37% of the mode of transmission of the identified abattoir zoonoses in slaughter animals (Fasanmi et al., 2017a).

This study is therefore aimed at determining the hygiene status of slaughterhouses, comparing the level of hygiene operations between abattoirs and slaughter slabs across Oyo State and to identify likely risk factors that may contribute to meat contamination during slaughtering and meat processing.

MATERIALS AND METHODS

Study locations

Oyo state is located in South Western Nigeria, with two distinct seasons namely; wet and dry seasons. The wet season is the period of rainfall, which is between April and October. The dry season covers between November and March and it is characterized by hot weather. The minimum, mean and maximum temperatures in Oyo State are 27, 31 and 35°C, respectively. The topography is about 0 to 500 m above sea level and the mean annual rainfall is within the range of 1000 to 1400 mm. Oyo State is bordered by Benin Republic in the west, in the North and East by Kwara and Osun States respectively and by Ogun State in the South. The State covers an area of approximately 27,000 km2. There are 33 local Government Areas (LGA) in Oyo State, all of which fall under four administrative zones-namely; Ibadan/Ibarapa, Oyo, Ogbomosho and Saki. Sixty slaughterhouses (abattoirs and slaughter slabs) were surveyed in three big cities of Oyo State. The cities include Ibadan (7° 24' 3'' N, 3° 51' 9'' E), Oyo (7° 51' 9.25" N, 3° 55' 52.50" E), Ogbomoso (8° 7' 60'' N, 4° 15' 0'' E). Sixty slaughterhouses were sampled from only 16 out of the 33 LGAs (Figure 1).

Preparation of checklist and locating slaughterhouses

This study was borne out of the need to prevent or possibly reduce the incidence of food poisoning; specifically meat poisoning through meat contamination at the slaughterhouses. The major cause of meat contamination has been attributed to poor hygiene and sanitation (Adeyemo, 2002). The drafting and preparation of this slaughterhouse hygiene and sanitation checklist was drawn from previous slaughterhouse-related studies in Africa (Cook et al., 2017; Okike et al., 2011), experience from slaughterhouse hygiene and operations in Nigeria, and recommendations for improvement on existing hygiene and structures.

A comprehensive checklist was developed based on three criteria: (i) Practical hygiene and sanitation at slaughter house, (ii) facilities, tools and equipments in use at slaughterhouse, and (iii) Operational Policies and regulations. A total of 50 items were identified and included in the checklist after the removal of duplicates and these were arranged based on the three criteria previously stated to determine and evaluate the level of compliance.

The prepared checklist was tested among the penultimate final year veterinary students of the University of Ibadan, Ibadan. Thereafter, the pretested checklists were administered by trained personnel (veterinarians and animal health technologist) in slaughterhouse in three major cities of Oyo State. The slaughterhouses were selected to include those located in both urban and rural areas; and they include abattoirs (licenced area where livestock are slaughtered under relatively hygienic condition in urban areas) and slaughter slabs (a location or makeshift arena where animals are slaughtered, especially in rural areas). Permissions were sought from all the slaughterhouses before the administration of the checklists.

Study design, sampling procedure and scoring of the checklist

A cross sectional survey was carried out by trained personnel using 50-item pre-tested and well structured checklist in slaughterhouses located across sixteen (16)

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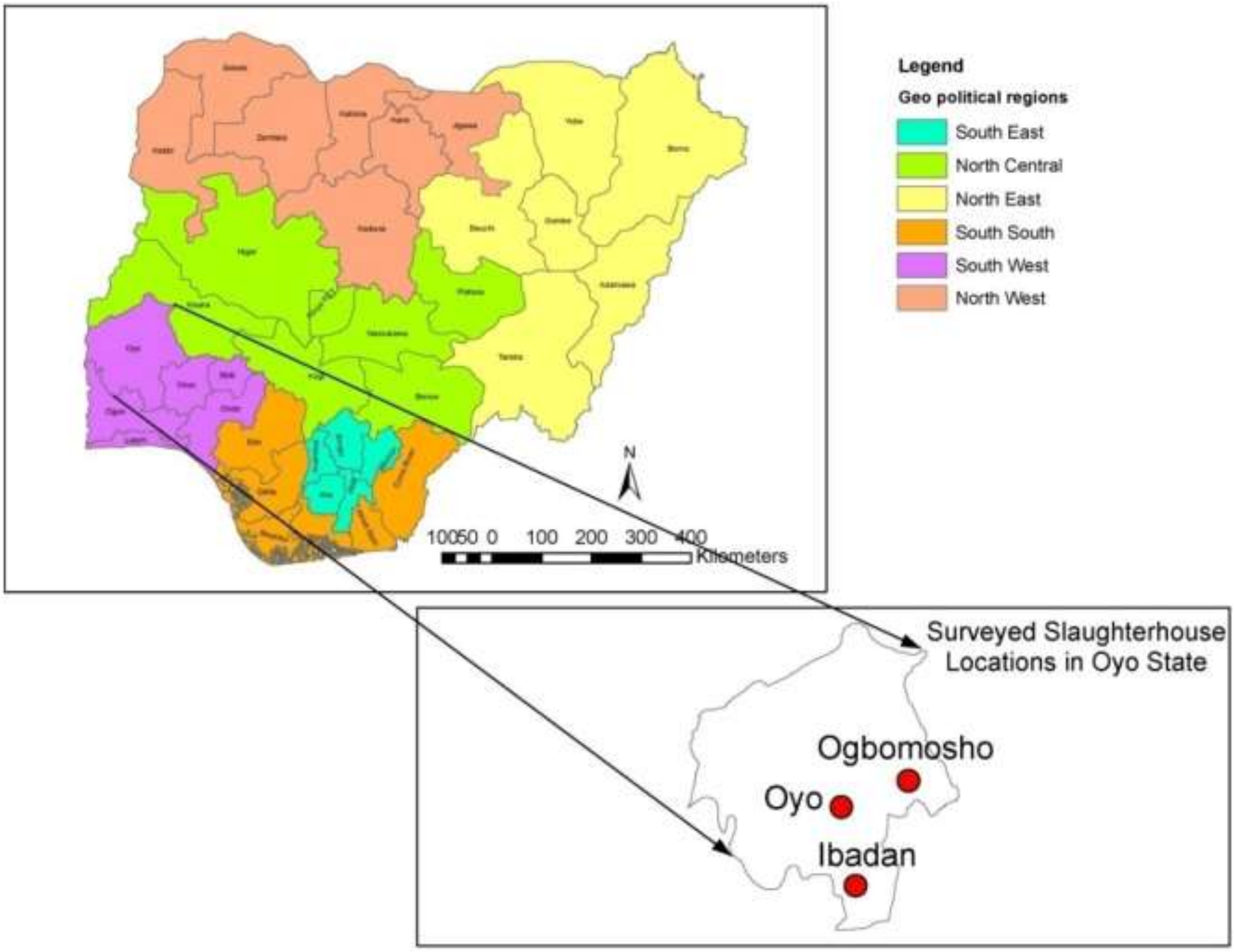

Figure 1. Map of Nigeria showing surveyed slaughterhouse locations in Oyo State.

local government areas. These local government areas are located in 3 cities that include Ibadan, Oyo and Ogbomosho. Sixty (60) slaughterhouses were purposively sampled from these cities. All selected slaughterhouses were visited between April and August, 2017. The number of slaughterhouse sampled was dependent on the number of slaughterhouse per city. Thirty seven (37) slaughterhouses were sampled in Ibadan, seventeen (17) in Oyo and six (6) in Ogbomosho. The 50-item pre-tested and well-structured checklist was scored as follows; observed practical hygiene and level of sanitation compliance: Non-existent to poor (0-49%) and good to very good (50-100%). For any slaughterhouse to be scored as having complied with any item, such a slaughterhouse must have scored ≥ 50%.

Source of data and data analyses

To obtain information, questions were asked by trained personnel from the butchers and workers of the slaughterhouse according to the drafted checklist, while the hygiene and operations were observed and each item was scored accordingly. The scores were categorized into two; either < 50 (non-existent to poor) or ≥ 50 (good to very good).

All scores were entered into Microsoft Excel® (Microsoft Redmond, USA) and analyzed using descriptive statistical program for proportions (in percentage); and t-test to check for significant differences for practical hygiene and level of sanitation between slaughter slabs and Abattoirs in Oyo State. But for the purpose of convenience and to prevent clumsiness of the graph, the figures in percentages were regarded thus; 0 - 24 = 1, 25 - 49% = 2, 50 - 74 = 3 and 75 - 100% = 4.

RESULTS

The overall results show that the majority of the

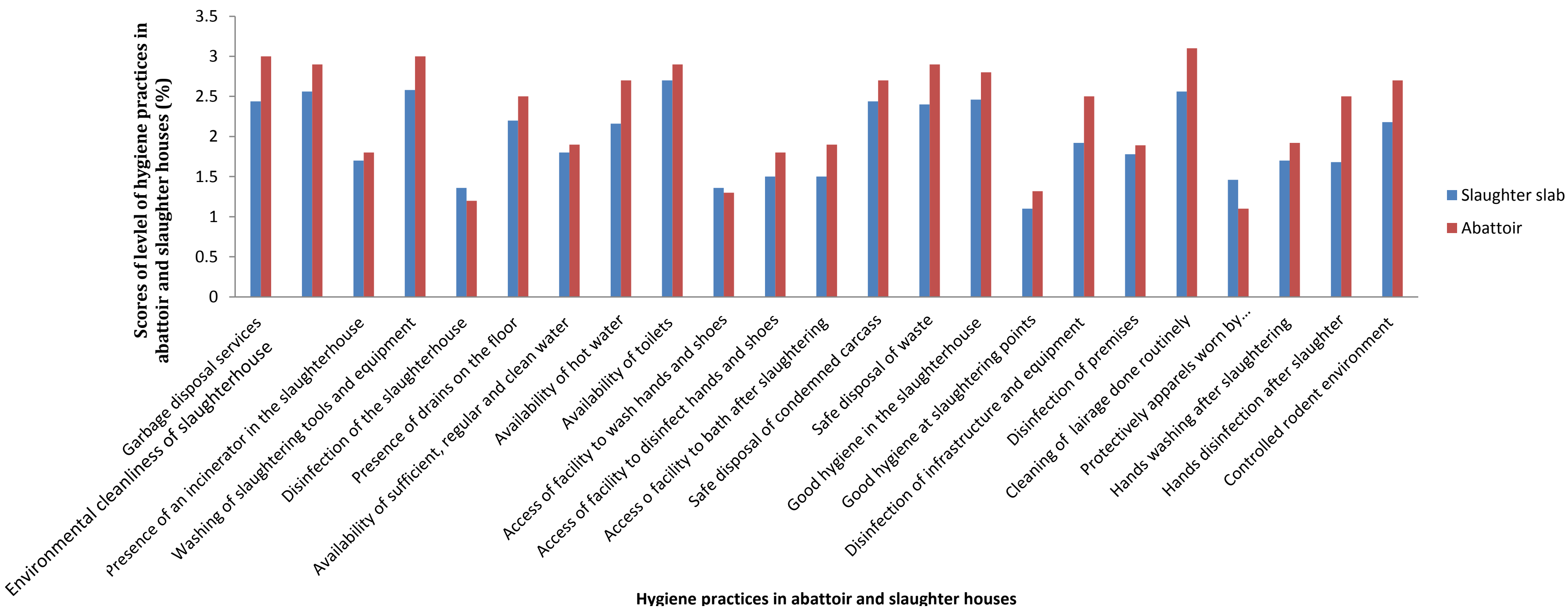

Figure 2. Graphical comparison of practical hygiene and level of sanitation at the abattoirs and slaughter slabs.

slaughterhouses in Oyo state performed poorly in the scoring of the entire 50-item checklist in the surveyed locations and final assessment. However some significant differences ($p < 0.05$) were observed when these items were compared between the abattoir and slaughter slabs in the operational hygiene and sanitation in Oyo state (Figure 2).

Practical hygiene and sanitation at slaughterhouses

Majority of the items scored for the slaughterhouses are between non-existent and poor, especially garbage disposal services (58.3% of the surveyed slaughterhouses), disinfection of slaughterhouse (100%), infrastructure and equipments (51.7%), disinfection of premises (98.3%) and hands after slaughter (71.7%), safe disposal of waste (86.7%) and controlled rodent environment (83.3%). Other scored items that fall within non-existent to poor are presence of incinerators (95%), floor drains (63.4%), availability of sufficient, regular and clean water (88.3%), hot water (71.7%) and toilets (66.7%), access to facility to bath after slaughtering (90%), to disinfect hands and shoes (96.7%) and safe disposal of waste (86.7%) and condemned carcass (96.7%). While on the other hand, only three of the scored items are good or very good; they include environmental cleanliness of slaughterhouse (66.7%), washing of slaughtering tools and equipments (60%) and access to facility to wash hands and shoes (71.7%) (Table 1).

Facilities, tools and equipments in use in slaughterhouses

Only one of the items (appropriateness of location of slaughterhouse) has a score categorized as

Table 1. Practical hygiene and level of sanitation at slaughterhouses in Oyo State.

S/N	Variable	Score < 50	Score ≥ 50	Remark
1	Garbage disposal services	35(58.3)	25(41.7)	Poor
2	Environmental cleanliness of slaughterhouse	20(33.3)	40(66.7)	Good
3	Presence of an incinerator in the slaughterhouse	57(95.0)	3(5.0)	Poor
4	Washing of slaughtering tools and equipment	24(40.0)	36(60.0)	Good
5	Disinfection of the slaughterhouse	60(100)	0(0.0)	Poor
6	Presence of drains on the floor	38(63.4)	22(36.6)	Poor
7	Availability of sufficient, regular and clean water	57(95.0)	3(5.0)	Poor
8	Availability of hot water	43(71.7)	17(28.3)	Poor
9	Availability of toilets	40(66.7)	20(33.3)	Poor
10	Access of facility to wash hands and shoes	43(71.7)	17(28.3)	Poor
11	Access of facility to disinfect hands and shoes	58(96.7)	3(3.3)	Poor
12	Access of facility to bath after slaughtering	54(90.0)	6(10.0)	Poor
13	Safe disposal of condemned carcass	58(96.7)	2(3.3)	Poor
14	Safe disposal of waste	52(86.7)	8(13.3)	Poor
15	Good hygiene in the slaughterhouse	36(60.0)	24(40.0)	Poor
16	Good hygiene at slaughtering points	32(53.3)	26(46.7)	Poor
17	Disinfection of infrastructure and equipment	31(51.7)	29(48.3)	Poor
18	Disinfection of premises	59(98.3)	1(1.7)	Poor
19	Cleaning of lairage done routinely	60(100)	0(0.0)	Poor
20	Protective apparels worn by slaughter/ processing persons	41(68.3)	19(31.7)	Poor
21	Hands washing after slaughtering	48(80.0)	12(20.0)	Poor
22	Hands disinfection after slaughter	43(71.7)	17(28.3)	Poor
23	Controlled rodent environment	50(83.3)	10(16.7)	Poor

Scores: Non- existent to poor (0-49%) or < 50; Good to very good (50-100%) or ≥ 50.

Table 2. Facilities, tools and equipment in use at slaughterhouses in Oyo State.

S/N	Variable	Score< 50	Score≥ 50	Remark
1	Lairage usage in the slaughterhouse	47(78.3)	13(21.7)	Poor
2	Resting of livestock before slaughtering and processing	34(56.7)	26(43.3)	Poor
3	Appropriateness of location of slaughterhouse	25(41.7)	35(58.3)	Good
4	Fencing and gates around the slaughterhouse	48(80.0)	12(20.0)	Poor
5	Isolation of abattoir from residential houses/markets	40(66.7)	20(33.3)	Poor
6	Compartmentalization of slaughterhouse	37(61.7)	23(38.3)	Poor
7	Availability of cold chain	58(96.7)	2(3.3)	Poor
8	Availability of lairage facility	38(63.3)	22(36.7)	Poor
9	Water delivery system in place in the slaughterhouse	32(53.3)	28(46.7)	Poor
10	Disinfection of lairage done routinely	58(96.7)	2(3.3)	Poor
11	Disinfection of equipments used for slaughtering	60(100)	0(0.0)	Poor
12	Slaughterhouse design	36(60.0)	24(40.9)	Poor
13	Enough space for future expansion	30(50.0)	30(50.0)	Fair
14	Location of water source	34(56.7)	26(43.3)	Poor

Scores; Non- existent to poor (0-49%) or < 50; Good to very good (50-100%) or ≥ 50.

good (58.3% of the slaughterhouses complied), and enough space for expansion is just fair (50%) (Table 2). All other items scored that are non-existent to poor, lairage usage (78.3% of the slaughterhouses underutilize them), non-resting of livestock before slaughtering (56.7%), non-compartmentalization of slaughterhouse

Table 3. Operational policies and regulations in slaughterhouses in Oyo State.

S/N	Variable	Score< 50	Score≥ 50	Remark
1	Monitoring of stages of slaughtering activities	51(85.0)	9(15.0)	Poor
2	Documentation of numbers of livestock slaughtered	20(50.0)	30(50.0)	Fair
3	Level of education of operators	55(91.7)	5(8.3)	Poor
4	Ratio of inspectors to slaughtered animals	51(85.0)	9(15.0)	Poor
5	Ratio of support staff to slaughtered animals	35(58.0)	25(41.7)	Poor
6	Access to veterinary inputs	48(80.0)	12(20.0)	Poor
7	All in all out policy in slaughterhouse	53(88.3)	7(11.7)	Poor
8	Separation of sick animals	51(85.0)	9(15.0)	Poor
9	Separation of different species of animals slaughtered	53(88.3)	7(11.7)	Poor
10	Restriction of movement of operators within the slaughterhouse	39(65.0)	21(35.0)	Poor
11	Compensation mechanism in place for condemned carcass	54(90.0)	6(10.0)	Poor
12	Monitoring of the state of health of operators	49(81.7)	11(18.3)	Poor
13	Regulation of environmental waste/effluent disposal	41(68.3)	19(31.7)	Poor

Scores; Non- existent to poor (0-49%) or < 50; Good to very good (50-100%) or ≥ 50.

(61.7%), non-availability of cold chain (96.7%), disinfection of equipments (100%), poor location of water source (56.7%) and other items scored under this category fall within non-existent to poor.

Operational policies and regulations in slaughterhouses

General scoring of the items here is poor, out of the thirteen items in this class, just one item (documentation of numbers of livestock slaughtered) is rated 50% and fairly complied with in the slaughterhouses. All other scored items which include; non-monitoring of stages of slaughtering activities (85%), poor level of education (91.7% of the slaughterhouses), bad ratio of inspectors to slaughtered animals (85% of slaughterhouses), all in all out policy not practiced (88.3%), non-separation of sick animals (85%), non-restriction of movement of operators (65% of slaughterhouses), non-monitoring the state of health of operators (81.7%) and non-regulation of environmental waste/effluent disposal (68.3%) fall within non-existent to poor (Table 3).

Comparison of practical hygiene and sanitation at the abattoirs and slaughterhouse slabs

Out of the twenty three items considered, only nine showed significant differences ($p<0.05$) between the abattoirs and slaughter slabs. The nine items are garbage disposal services ($p<0.001$), washing of slaughtering tools and equipments ($p<0.001$), disinfection of the slaughterhouse ($p<0.014$), disinfection of premises ($p<0.001$) and disinfection of infrastructures and equipments ($p<0.002$). Others are, availability of sufficient, regular and clean water ($p<0.001$), good hygiene in the slaughterhouse ($p<0.033$) and also, hands washing after slaughter ($p<0.001$) and hands disinfection after slaughter (0.001) (Figure 2 and Table 4).

DISCUSSION

Slaughterhouses are licensed key locations where slaughter animals are slaughtered for human consumption, under the supervision of inspectors. At the slaughterhouses there are possibilities of different degrees of contamination (Adeyemo, 2002). Due to variations in slaughterhouse contaminations across Nigeria, Okike et al. (2011) inferred that only 2% of meat samples processed from slaughterhouses in the country complied with acceptable meat standards and hence are not contaminated.

Meat has been classified as a first class protein, recommended at 0.75 g per kilogram body weight per day, as the requirement to maintain healthy living (maintenance and repairs of worn out tissues) among others (FAO, 2003). When meat is properly prepared it is useful, nutritive, wholesome and fit for human consumption (Govindarajan, 1990; FAO, 2016), but if not may serve as medium for disease propagation (Mensah et al., 2012). The slaughtering of meat animals, preparation of meat, the environment for meat preparation and the distribution of meat must be carried out in a hygienic manner with minimal contamination (Skaarup, 1985). However, meat produced in an unhygienic condition could pose threat to the health of the consumers as well as compromise the keeping quality of such meat, thereby affecting the shelf life and wholesomeness of meat produced (Govender, 2014).

The proper disposal of condemned carcasses and

Table 4. Differences in practical hygiene and level of sanitation at the abattoirs and slaughter slabs in Oyo State.

S/N	Variable	Slaughter slab	Abattoir	p-value
1	Garbage disposal services	2.24	3.00	0.001*
2	Environmental cleanliness of slaughterhouse	2.56	2.90	0.059
3	Presence of an incinerator in the slaughterhouse	1.70	1.80	0.058
4	Washing of slaughtering tools and equipment	2.58	3.00	0.001*
5	Disinfection of the slaughterhouse	1.20	1.36	0.014*
6	Presence of drains on the floor	2.20	2.50	0.720
7	Availability of sufficient, regular and clean water	1.80	1.90	0.001*
8	Availability of hot water	2.16	2.70	0.582
9	Availability of toilets	2.70	2.90	0.843
10	Access of facility to wash hands and shoes	1.36	1.30	0.269
11	Access of facility to disinfect hands and shoes	1.50	1.80	0.958
12	Access of facility to bath after slaughtering	1.50	1.90	0.565
13	Safe disposal of condemned carcass	2.44	2.70	0.821
14	Safe disposal of waste	2.40	2.90	0.208
15	Good hygiene in the slaughterhouse	2.46	2.80	0.033*
16	Good hygiene at slaughtering points	1.10	1.32	0.847
17	Disinfection of infrastructure and equipment	1.92	2.50	0.002*
18	Disinfection of premises	1.78	1.89	0.001*
19	Cleaning of lairage done routinely	2.56	3.10	0.866
20	Protective apparels worn by slaughter/ processing persons	1.46	1.10	0.070
21	Hands washing after slaughtering	1.70	1.92	0.001*
22	Hands disinfection after slaughter	1.68	2.50	0.001*
23	Controlled rodent environment	2.18	2.70	0.526

* Significant at $p < 0.05$.

wastes in a safe area and installations of incinerators are contributory to the success of slaughterhouses across the world, because these practices will prevent the littering of the environment with disease causing agents, which can be persistent (Bengtssom and Whitttaker, 1988). Observations revealed that majority of the slaughterhouses sampled (95%) lack the listed facilities and disposal of condemned carcasses and wastes indiscriminately within the slaughterhouse environment. Most of the time these carcasses and wastes are littered not far from the water sources; there are usually high possibility of microbial contamination of the environment and the water for processing (Kwadzah and Iorhemen, 2015).

Potable water is essential for the smooth running of any slaughterhouse and must be readily accessible during slaughtering, for cleaning, and washing of slaughtering equipments and workers' hands with proper disinfection (CAC, 2003). Also, hot water from pressure hose is needed for some level of disinfection for use at the slaughterhouse (FAO, 1985). These processing activities will need pipe-borne water or well cited and properly sunk bore-holes that are only available in very few slaughterhouses in Oyo State; this study observed that the use of hot water is not a common practice for disinfection. There was lack of water, no hand washing facilities, and no proper disinfection in most slaughterhouses, so majority of the slaughterhouse workers hardly observe these hygienic routines.

Previous studies have shown that hand washing is practiced in order to protect carcass/meat from getting contaminated and this practice also confer some levels of protection of the worker against direct infection from certain microbes such as *E. coli* and *Salmonella* sp. (Gomes-Neves et al., 2012). The washing of slaughtering tools and equipments is normally done, but there is lack of disinfection culture amongst the operators and butchers. This practice will allow the persistence of microbes on knife, cutting surfaces and wearing apparels, which can lead to contamination of carcass and meat (EC, 2001). It was also observed that most of the slaughterhouses lack facilities to wash and disinfect hands and shoes, and also majority of them do not have bath rooms and toilets; all these have public health implications to workers and the community at large.

The presence of rodents and other animals in and around the slaughterhouse will favour the transmission of abattoir infectious or zoonotic disease and can lead to persistence and spread of such diseases in the slaughterhouse environment (Bengtssom and Whittaker, 1998).

The protective apparels worn by the meat handlers in the slaughterhouse are meant to prevent contamination of the carcass/meat products and vice versa due to the vulnerability of the meat handlers to occupational hazards (EC, 2001). Barely 32% of meat handlers wear protective apparels during slaughtering and meat processing, and they claim ignorance of not having any knowledge of occupational hazards.

Most structures needed for slaughterhouses are present, except toilets which are not common finding in most of the slaughterhouses, but are not put into proper use. Water supply is very poor, in most cases stream and poorly dug and cited wells are used, most of which are already contaminated by surface run-offs and poorly discharged effluents (Nafarnda et al., 2012).

There are differences between availability of lairages and usage of lairages; the lairage is the first section of a slaughterhouse where slaughter animals are rested and inspected prior to slaughtering (Heinz, 2008). Majority of the slaughterhouses lack lairage facilities, whenever it is present it is either under-utilized or not put into use, and most of the time it is in a deplorable state with very poor level of hygiene. Majority of the lairages in slaughterhouses in Oyo State are not routinely cleaned, this further supports the findings of previous studies, that most slaughterhouses in Nigeria do not have functional lairages (Lawan et al., 2013). Also, the usage of lairage if present at all for resting of livestock before slaughtering is poor, which is in line with the assertion of Adeyemo et al. (2009), that lairage has been largely implicated as a point for cross contamination among animals being rested after transportation from long distance.

In an ideal setting, there should be compartmentalization of the slaughterhouse, especially between the dirty (killing and bleeding sections) and clean (eviscerating and splitting sections) to forestall carcass contamination (CAC, 2003). But on the contrary, majority of the slaughterhouses in the surveyed areas carry out all their operations (slaughtering, bleeding, skinning, evisceration, and carcass splitting) on the same spot. This type of operation and practice will lead to contamination of carcasses due to traffic flow against the normal directional flow and likelihood of contamination of carcass and the environment where there are human habitations (Spickler, 2016).

Meat inspection and monitoring of slaughtering operations are crucial for the detection of slaughterhouse diseases, contaminated carcass/meat and facilities/ equipments (CAC, 2003; Ninios et al., 2014). Due to absence of or insufficient meat inspectors in most of the slaughterhouses, most of the operations and slaughtering activities are carried out without proper supervision, which is contrary to the recommended regulations (Komba et al., 2012; Cook et al., 2017). This prevents thorough ante-mortem inspection, which is essential for preventing the slaughter of sick animals, post-mortem inspection for detailed carcass and organ examination to detect signs of disease; and facility and hygiene inspection to detect flaws in operational hygiene. Slaughtering infected animals has been shown to be a risk factor for infection with possibility of causing zoonosis (Brown et al., 2011).

The level of education of the slaughterhouse operators across the sampled locations is very low (8.3%), this will make it difficult for them to be able to comprehend the reasons behind certain activities. Alhaji and Baiwa (2015) emphasize the importance of education and knowledge in operational hygiene, that lack of knowledge vis-a-vis hygiene during meat processing and meat contamination will ultimately affect the quality of the meat derived thereof. The training of slaughterhouse operators in the acquisition of knowledge and understanding of the importance of hygiene during slaughtering and meat processing so as to improve the level of cleanliness and operational hygiene in slaughterhouses; and thus leading to the reduction of microbial contamination of carcass/meat (Wamalwa et al., 2012).

The slaughterhouses are poorly staffed, right from the veterinary inputs, inspectors to support staff, which has negative effects on the monitoring of the stages of slaughtering activities. The policy of all in all out is rarely observed, so also the separation of different slaughter animal species and sick from healthy animals.

If the role and response of the government in the compensation for condemned carcasses is not good enough, stake holders in the slaughterhouse will not be willing to submit condemned carcass for destruction; this infected carcass will be sold to unsuspecting public and residents of surveyed locations who stand high risk of contracting infections or zoonotic diseases through consumption of contaminated meat (Qekwana et al., 2017). The monitoring of the state of health of slaughterhouse operators (especially wounds that can also contaminate carcass/meat and that could predispose further to occupational diseases) is very poor across the sampled locations.

Animal health personnel, slaughterhouse workers and other stakeholders in the slaughterhouse are also at high risk of exposure to certain zoonotic pathogens which can infect them, and render them carriers of the zoonoses that can be spread to other human population living with them in the same community (Lejeune and Kersting, 2010).

Based on previous studies, hygiene and sanitation are better practiced at the abattoir when compared with the slaughter slabs; this has been attributed to many factors, among which are; construction and compartmentalization of the abattoir, which reduces the level of contamination during slaughtering and processing (CAC, 2003). The identification of critical control points (CCPs) helps to counter the hazards/risks of contamination in the slaughterhouse (CAC, 2003; Govender, 2014). Hazard Analysis and Critical Control Point (HACCP) is a system for food safety management. It is a preventative approach to food safety (FSA, 2005).

Fasanmi et al. (2017b), identified more CCPs (12) for abattoir when compared with the slaughter slab (9) with muddled up activities during slaughtering, thereby leading to difficulties in the monitoring, prevention and control of probable hazard(s). The numbers of CCPs positively correlate with level of hygiene and cleanliness; and hence there is lower tendency of contamination. This is why there is always higher incidence of carcass and/or meat contamination in slaughter slabs when compared with the abattoirs. These studies further corroborate the previous findings.

Also the availability of sufficient, clean and regular water supply has positive correlations with washing of slaughtering tools and equipments, and hands washing after slaughtering. These are better done in the abattoir than the slabs across the surveyed slaughterhouses. Disinfection is different from washing; disinfection reduces the microbial loads on contaminated surfaces in slaughterhouses (Connor et al., 2017); this study shows that the disinfection of the slaughterhouse, the disinfection of hands after slaughtering, disinfection of the premises and equipments were also better done at the abattoir than the slabs. The reasons for all the aforementioned could not be farfetched; a lot of attention is paid to the abattoir because of they are established by the Municipal or local government council and having enough inspectors and support staff courtesy of the municipal and regulatory authorities that also make provisions for facilities, amenities and infrastructures (Davey, 1989).

Conclusion

All evidences of unhygienic practices and the risk factors in slaughterhouses across sampled locations is an indication that majority of the abattoirs or slaughter slabs are contaminated. By implication, the meats derived thereof are unwholesome and not safe. This implies that the slaughterhouses are non-compliant with the established regulations governing the establishment and operations of slaughterhouse. These locations may serve as critical points for the distribution of contaminated meat to the unsuspecting public and also medium where unprotected and vulnerable abattoir workers are exposed to occupational diseases. Hence, this has called to question the issue of food safety in the surveyed slaughterhouses across Oyo State, South Western Nigeria. Therefore, there is the need for slaughterhouse workers to be trained and retrained on occupational zoonoses and the relevance of hygiene and sanitation of slaughterhouse operations in the production of wholesome meat, before they are released for human consumption. The provision of facilities and infrastructures, such as toilets, bathrooms, incinerators and good sources of water by the government or private slaughterhouse owners is a necessity.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

REFERENCES

Adeyemo OK (2002). Unhygienic operation of a city abattoir in South-western Nigeria: environmental implication. African Journal of Environmental Assessment and Management 4(1):23-28.

Adeyemo O, Adeyemi I, Awosanya E (2009). Cattle cruelty and risks of meat contamination at Akinyele Cattle Market and Slaughter Slab in Oyo State, Nigeria. Tropical Animal Health Product 41:1715-1721. https://www.ncbi.nlm.nih.gov/pubmed/19440852

Alhaji NB, Baiwa M (2015). Factors affecting workers' delivery of good hygienic and sanitary operations in slaughterhouses in north-central Nigeria. Sokoto Journal of Veterinary Sciences 13(1):29-37. https://www.ajol.info/index.php/sokjvs/article/viewFile/116254/105778

Bakhtiary F, Sayevand HR, Remely M, Hippe B, Hosseini H, Alexander G (2016). Evaluation of bacterial contamination sources in meat production line. Journal of Food Quality 39(6):1-7. http://onlinelibrary.wiley.com/doi/10.1111/jfq.12243/pdf

Bardosh KL, Scoones JC, Grace D, Kalema-Zikusoka G, Jones KE, de Balogh K, Waltner-Toews D, Bett B, Welburn SC, Mumford E, Dzingirai V (2017). Engaging research with policy and action: what are the challenges of responding to zoonotic disease in Africa? Philosophical Transactions of the Royal Society B, DOI: 10.1098/rstb.2016.0172. http://rstb.royalsocietypublishing.org/content/372/1725/20160172

Bengtssom LP, Whittaker JH, (1988). Farm structures in tropical climates. Rome: Food and Agriculture Organization of the United Nations. http://www.fao.org/docrep/s1250e/S1250E00.htm

Brown PD, McKenzie M, Pinnock M, McGrowder D (2011). Environmental risk factors associated with leptospirosis among butchers and their associates in Jamaica. The International Journal of Occupational and Environmental Medicine 2(1):47-57. https://www.ncbi.nlm.nih.gov/pubmed/23022818

Codex Alimentarius Commission (CAC) (2003). Recommended International Code of Practice: General Principles of Food Hygiene-CAC/RCP 1-1969, Rev. 4-2003, Annexure: Hazard Analysis and Critical Control Point (HACCP) System and Guidelines for its Application. FAO/WHO, Rome. http://www.fao.org/input/download/standards/23/CXP_001e.pdf

Connor JTO, Clegg TA, More SJ (2017). Efficacy of washing and disinfection in cattle markets in Ireland. Irish Veterinary Journal 70(6):1-6 https://doi.org/10.1186/s13620-017-0081-1

Cook EAJ, de Glanville WA, Thomas LF, Kariuki S, Bronvoort BM, Fevre EM (2017).Working conditions and public health risks in slaughterhouses in western Kenya. BMC Public Health 17(1):14. Doi: 10.1186/s12889-016-3923-y. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5217581/

Davey K (1989). Strengthening Municipal Government. The World Bank Policy, Planning and Research Staff. Infrastructure and Urban Development Department. Report INU 47. http://documents.worldbank.org/curated/pt/713521468765035493/pdf/multi-page.pdf

European Commission (EC) (2001). Opinion of the scientific committee on veterinary measures relating to public health, the cleaning and disinfection of knives in the meat and poultry industries. Health & consumer protection directorate-general.https://ec.europa.eu/food/sites/food/files/safety/docs/sci-com_scv_out43_en.pdf

Food and Agriculture Organization (FAO) (1985). Rep AlimentariusCommission. http://www.fao.org/input/download/report/344/al85_16e.pdf

Food And Agriculture Organization (FAO) (2003). Summary of requirements for energy and protein. http://www.fao.org/docrep/003/AA040E/AA040E09.htm

Food and Agriculture Organisation (FAO) (2015). Food safety: What you should know. World Health Day, SEA-NUT-196.

http://www.searo.who.int/entity/world_health_day/2015/whd-what-you-should-know/en/
Food and Agriculture Organisation (FAO) (2016). Abattoir development: Slaughter house hygiene problems and solutions. http://www.fao.org/docrep/010/ai410e/AI410E05.htm
Fasanmi OG, Ayodeji IO, Oloso NO, Fasina FO (2017a). Retrospective studies of abattoir zoonoses in Nigeria: Public health implications. CAB Rev. 12(58): 1-14. doi: 10.1079/PAVSNNR201712058
Fasanmi OG, Balogun FA, Makinde GEO, Fasina FO (2017b). Review of microbial zoonoses in Slaughterhouses and identified potential critical risk points along red meat processing chain in Nigeria. CAB Rev. 12(25):1-12. DOI:10.1079/PAVSNNR201712025
Food Standard Agency (FSA) (2005). HACCP in meat Plants.https://www.food.gov.uk/business-industry/meat/haccpmeatplants
Gomes-Neves E, Antunes P, Tavares A, Themudo P, Cardoso MF, Gärtner F, Costa JM, Peixe L (2012). Salmonella cross-contamination in swine abattoirs in Portugal: Carcasses, meat and meat handlers. International Journal of Food Microbiology 157(1):82-87. http://www.scielo.br/scielo.php?script=sci_nlinks&pid=S0100-736X201600120116500019&lng=en
Govender R (2014). A hazard analysis methodology for South African abattoir hygiene management system. British Food Journal, 116(12):2026-2047. http://dx.doi.org/10.1108/BFJ-01-2013-0023
Govindarajan CV (1990). Maintenance of hygienic and sanitary conditions including personal hygiene in the meat factory. Technical paper in First National Seminar on Marketing of Meat Food Products in India, Aligarh, India 1990.
Grace D (2015). Food safety in low and middle income countries. International Journal of Environmental Research and Public Health, 12:10490-507. http://www.mdpi.com/1660-4601/12/9/10490/pdf
Heinz G (2008). Abattoir development. Options and designs for hygienic basic and medium-sized abattoirs. Annex 7. http://www.fao.org/docrep/010/ai410e/ai410e00.htm
Koo OK, Mertz AW, Akins EL, Sirsat SA, Neal JA, Morawicki R, Crandall PG, Ricke SC (2013). Analysis of microbial diversity on deli slicers using polymerase chain reaction and denaturing gradient gel electrophoresis technologies. Letters in Applied Microbiology 56:111-119. http://onlinelibrary.wiley.com/doi/10.1111/lam.12021/full
Komba EV, Komba EV, Mkupasi EM, Mbyuzi AO, Mshamu S, Mzula A, Luwumba D (2012). Sanitary practices and occurrence of zoonotic conditions in cattle at slaughter in Morogoro Municipality, Tanzania: implications for public health. Tanzania Journal of Health Research 14(2). doi: 10.4314/thrb.v14i2.6. https://www.ncbi.nlm.nih.gov/pubmed/26591734
Kwadzah TK, Iorhemen OT (2015). Assessment of the Impact of Abattoir Effluent on the Water Quality of River Kaduna, Nigeria. World Journal of Environmental Engineering 3(3):87-94. DOI:10.12691/wjee-3-3-3. http://pubs.sciepub.com/wjee/3/3/3
Lawan MK, Bello M, Kwaga JKP, Raji MA (2013). Evaluation of physical facilities and processing operations of major abattoirs in North-western states of Nigeria. Sokoto Journal Veterinary Science 11(1):56-61. https://pdfs.semanticscholar.org/3898/63ef4fd127ba4e1deba0e00cf0205e36c03e.pdf
LeJeune J, Kersting A (2010). Zoonoses: an occupational hazard for livestock workers and a public health concern for rural communities. Journal of Agricultural Safety and Health 16(3):161-79. https://www.ncbi.nlm.nih.gov/pubmed/20836437
Lues JFR, Theron MM, Venter P, Rasephei MHR (2007). Microbial composition of bioaerosols of a high-throughput chicken slaughtering facility. Poultry Science 86:142-149. https://pdfs.semanticscholar.org/4e44/df5f7974f38e08f622127d1b95d0326e9b15.pdf
Malangu N (2016). Risk Factors and Outcomes of Food Poisoning in Africa. Agricultural and Biological Sciences ''Significance, Prevention and Control of Food Related Diseases. Book edited by Hussain Anthony Makun pp. 1-41. ISBN 978-953-51-2277-7 https://cdn.intechopen.com/pdfs-wm/49838.pdf
Mensah P, Mwamakamba L, Mohamed C, Nsue-Milang D (2012). Public health and food safety in the WHO African region. African Journal Food Agriculture Nutritional Development 12(4):1-19. http://www.bioline.org.br/pdf?nd12050
Nafarnda WD, Ajayi IE, Shawulu JC, KaweMS, Omeiza GK, Sani NA, Tenuche OZ, Dantong DD (2012). Bacteriological quality of abattoir effluents discharged into water bodies in Abuja, Nigeria. ISRN Veterinary Science pp 1-5. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3658817/
Ninios T, Lunden J, Korkeala H, Fredriksson-Ahoamaa M (2014). Meat Inspection and Control in the Slaughterhouse. 1ST Ed., Wiley-Blackwell Publishers. ISBN: 978-1-118-52586-9. https://www.amazon.com/Inspection-Control-Slaughterhouse-Thimjos-Ninios/dp/1118525868.
Okike I, Grace D, Mohammed H, Dipeolu M, Poole J, Gachohi J, Baker D, Lore T, Rushton J, Makita K (2011). Assessment of risks to human health associated with meat from different value chains in Nigeria: using the example of the beef value chain. https://cgspace.cgiar.org/bitstream/handle/10568/10251/Final%20Report%20-%20Nigeria%20Meat%20Chain%20Study-ILRI.pdf?sequence=1
Qekwana DN, McCrindle CME, Oguttu JW, Grace D (2017). Assessment of the Occupational Health and Food Safety Risks Associated with the Traditional Slaughter and Consumption of Goatsin Gauteng, South Africa. International Journal of Environmental Research and Public Health 14:420.https://www.ncbi.nlm.nih.gov/pubmed/28420084
Schlegelova J, Nápravníková E, Dendis M, Horvath R, Benedík J, Babak V, Klímová E, Navratilova P, Šustáčková A (2004). Beef carcass contamination in a slaughterhouse and prevalence of resistance to antimicrobial drugs in isolates of selected microbial species. Meat science 66:557-565. SCHWAIGER, http://europepmc.org/abstract/med/22060865
Skaarup T (1985). Slaughterhouse cleaning and sanitation. Food and Agriculture Organization of the United Nations, Rome. http://www.fao.org/docrep/003/x6557e/X6557E00.htm
Spickler AR (2016). Transmission of Zoonoses Between Animals and People. Merck and theMerck Veterinary Manual. Merck & Co., Inc., Kenilworth, NJ, USA.http://www.merckvetmanual.com/public-health/zoonoses/transmission-of-zoonoses-between animals-and-people#v3357761
Wamalwa K, Castiello M, Ombui JN, Gathuma J (2012). Capacity building: benchmark for production of meat with low levels of bacterial contamination in local slaughterhouses in Somali land. Tropical Animal Health Product 44(3):427-433. https://www.ncbi.nlm.nih.gov/pubmed/21779942
World Health Organisation (WHO), (2015). WHO's first ever global estimates of foodborne diseases. http://www.who.int/mediacentre/news/releases/2015/foodborne-disease-estimates/en/

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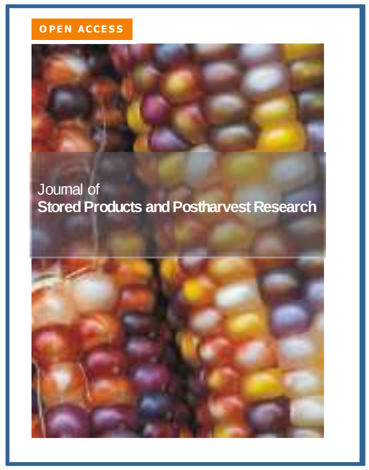

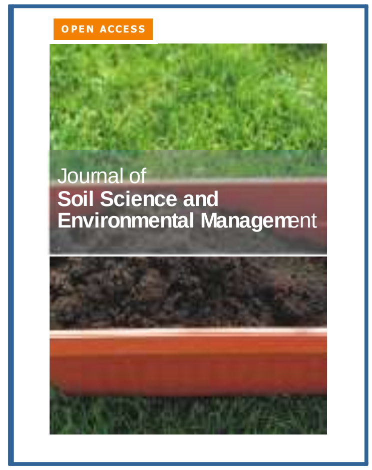

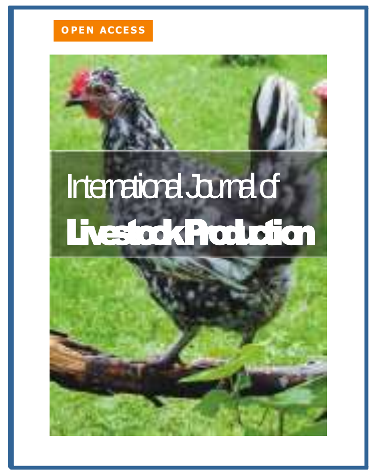

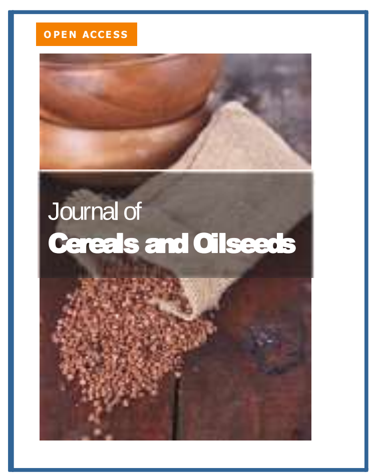

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